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1 HAVO|VWO deel A

Biologie voor jou TTO

BIOLOGIE VOOR TWEETALIG ONDERWIJS

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Getting started with *Biologie voor jou TTO*

Biology is all around you. *Biologie voor jou TTO* puts all the tools within easy reach that you need for experiencing, enjoying and discovering it! The introductory chapter first tells you what biology is about, why the subject is important and what you can do with it.

1 Organisms

LEARNING OBJECTIVES

1.1.1 You can explain what an organism is.
 1.1.2 You can list the seven life processes.
 1.1.3 You can distinguish between things that are living, dead or non-living (never alive).

► Learning how to do research 1
 ► Practical activity 1

TAXONOMY	1.1.1	1.1.2	1.1.3
Remembering	1a	2	
Understanding	1bc, 5	3, 5	4, 5
Using	10b	7a, 8, 10ac	6
Analysing		7bc, 9	7bc

The Greek word for life is *bios* and *logos* means a study or science. Together these two words make 'biology': the study of life.

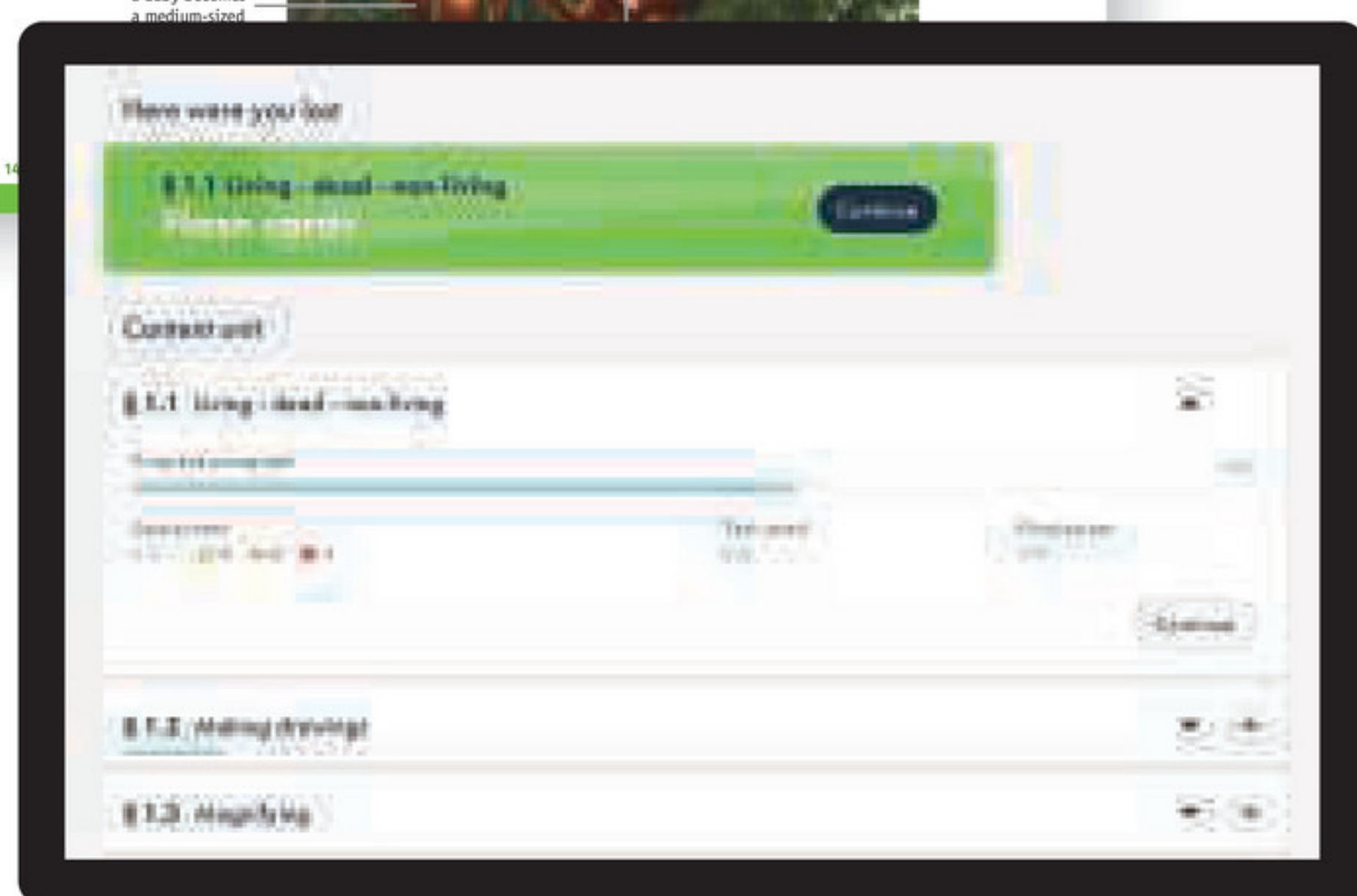
LIVING CREATURES

Biology is about organisms. An **organism** is a living creature. Humans, animals and plants are organisms, just like bacteria and fungi are. All organisms have **life processes**. The life processes tell you whether something is **living** and therefore an organism. A stone does not have life processes, so a stone is not an organism.

You can see the life processes of an orang-utan in figure 1. The seven life processes are:

- breathing
- feeding
- excreting
- sensing
- moving
- reproducing
- growing

fig. 1 Life processes in an orang-utan.



7 The importance of photosynthesis

LEARNING OBJECTIVE

1.7.16 You can explain that many fuels and raw materials exist thanks to photosynthesis.

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
Remembering	1.7.16
Understanding	1a
Using	1bcd, 2, 3
Analysing	

Plants can make glucose by photosynthesis. The plant can use glucose to make other substances. People depend on raw materials that were created thanks to photosynthesis.

FUELS

Natural gas, petroleum and coal are commonly used fuels. Petroleum is used to make petrol for cars. Many homes still have boilers that use natural gas. Coal is mainly used as fuel in power plants.

These fuels were formed from the remains of dead organisms that ended up on the sea bed millions of years ago. There they got compressed more and more by new layers of sand. The high pressure and heat changed the remains into coal, petroleum and natural gas. These are called **fossil fuels** (see figure 1). Fossil fuels originated from organisms that could live and grow thanks to photosynthesis.

fig. 1 Fossil fuels.



Work in your book *and* work online!

There are two books for each school year plus an online learning environment. Your teacher will decide what you do online (with a laptop, tablet or phone) and what you do in your book.

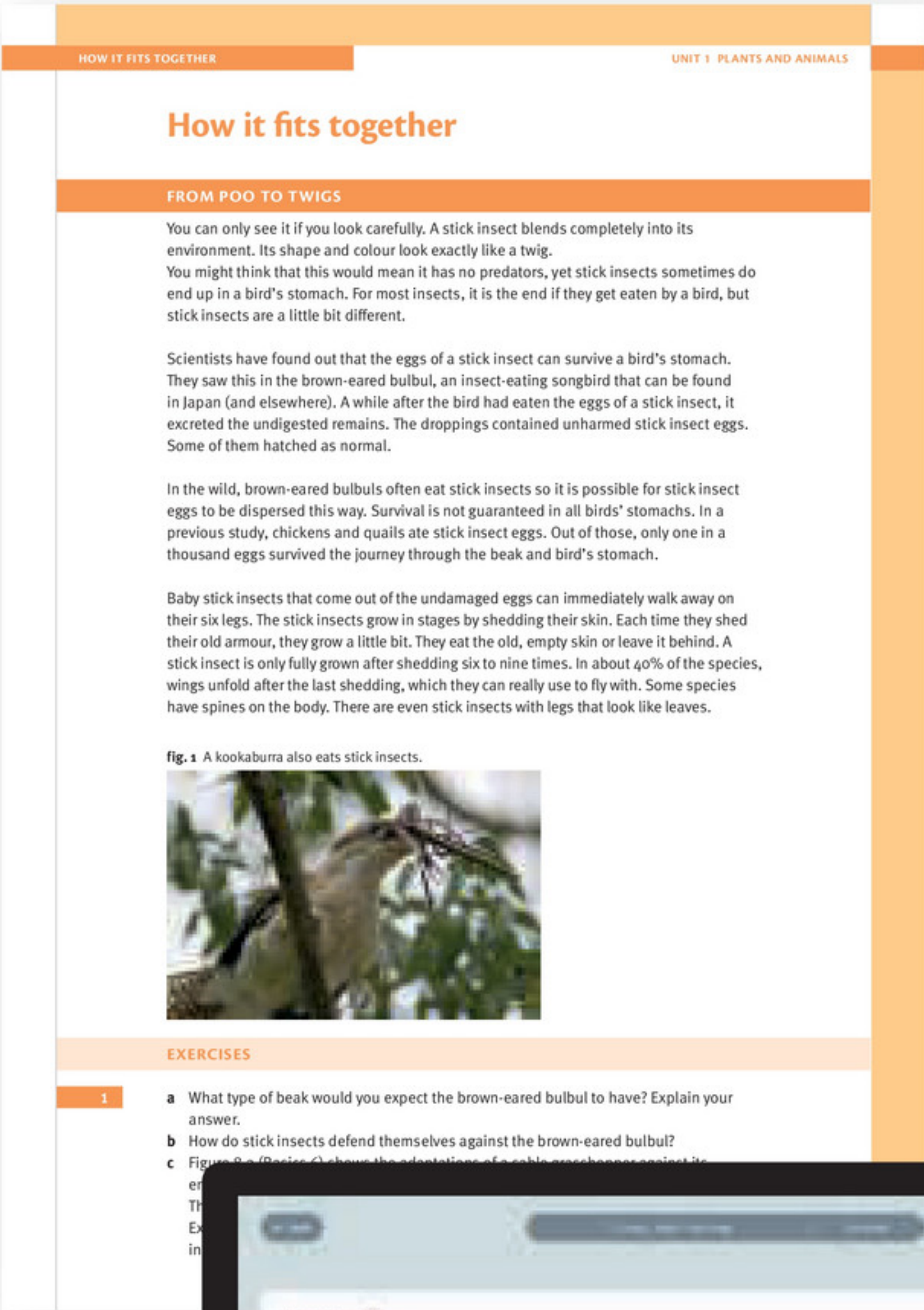
Each unit is split up into a Basics section, an Extra section, practical activities and a closing section. Learning objectives are always given at the start, telling you what you are going to learn and what level of taxonomy you will be using in the practical activities for the material you have learned. You can do the Extra sections if you want to know more or are feeling curious or have some spare time. In the activities section, you will do exercises and learn how to study and do research.

The advantages of working online

- You quickly see what you are doing correctly and what you are doing wrong.
- You get feedback on your answers straight away.
- You can watch video clips and animated clips.
- You learn the concepts and test yourself using the *Flash cards*.
- You can use the *Test yourself* sections, the practice test and the diagnostic test to see if you have understood the material.
- You can work at a higher or lower level or for a different school year.
- Your teacher will monitor how you are doing.

How it fits together

There is a section called *How it fits together* at the end of each Basics section and after all the Basics sections as a whole. These are in an orange frame. The way things fit together shows you why the course material is important in the world around you. You also learn to see connections between the information in the various Basics sections.

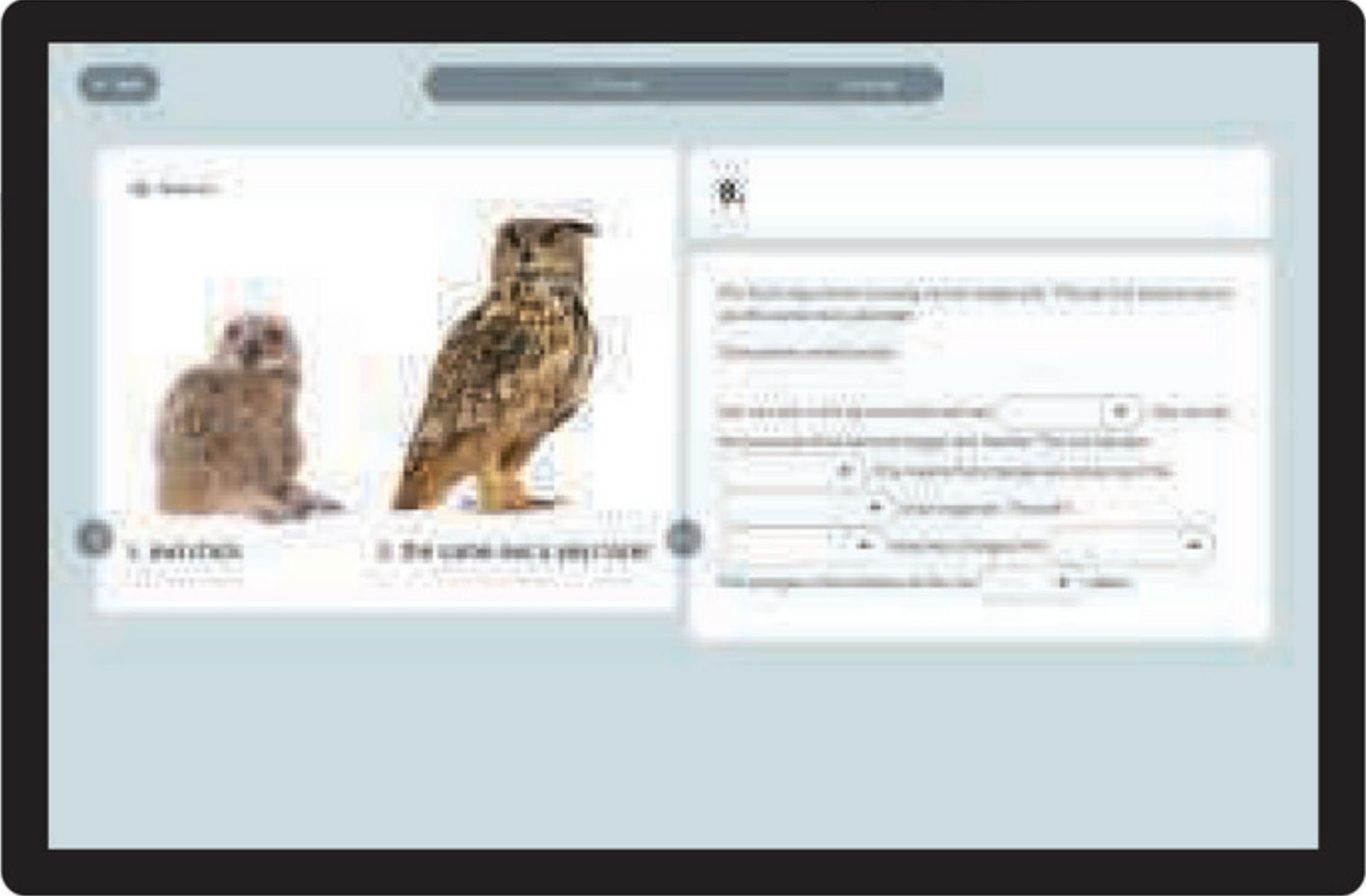
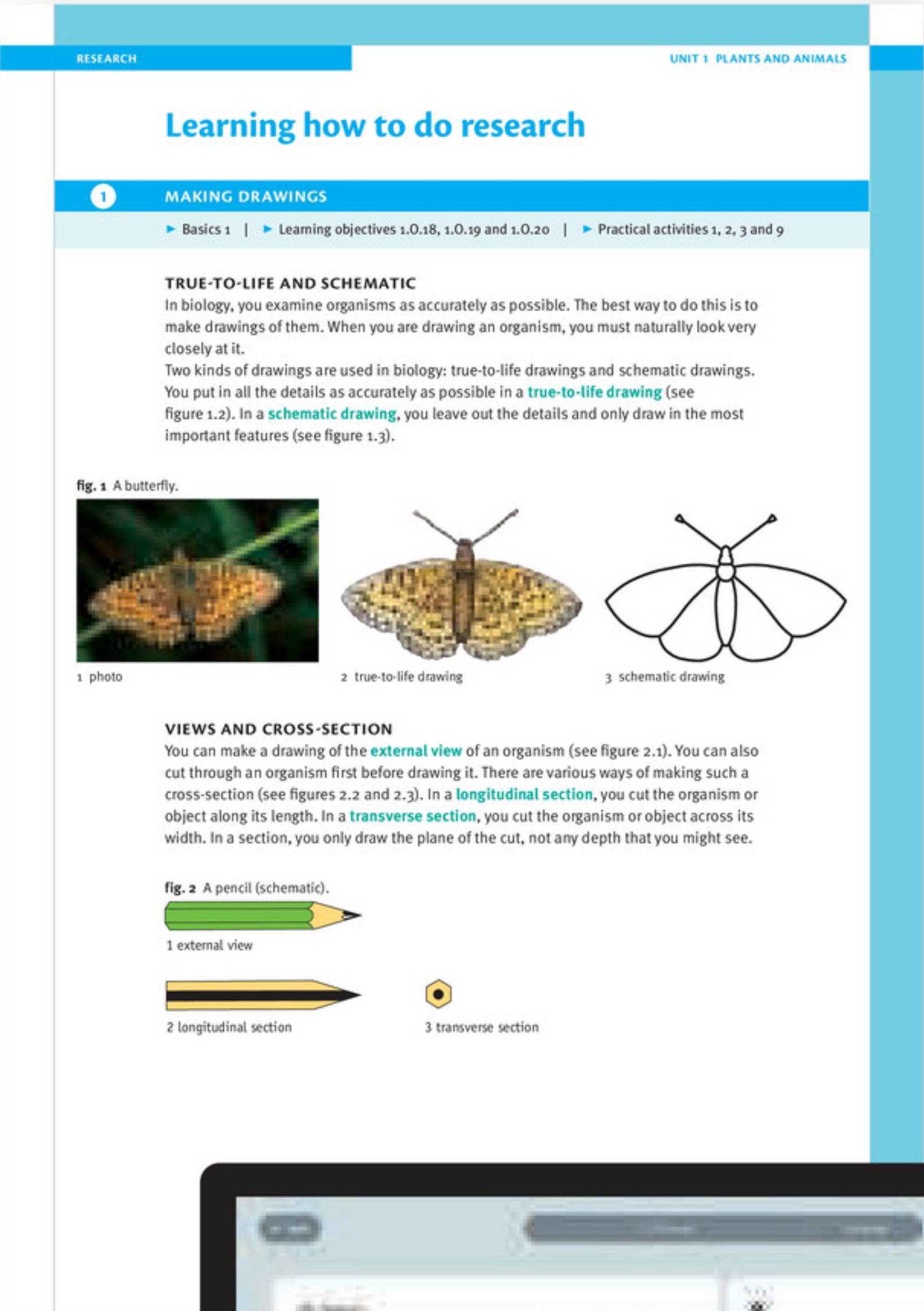


The advantages of the book

- You get a quick overview of what you will be learning.
- You can read the longer texts on paper.
- You can annotate the text and add remarks.
- You will be making drawings and adding colour yourself, which helps you remember things better.

Good preparation for the test!

The units end with a closing section (Summary). This is also where you can find the **Flash cards** for learning all the concepts. There is also a **Diagnostic test**. If you are not sure that you understand the material well enough, you can do the **Test yourself** section or the **Practice test**.



Meaning of the symbols

- This exercise is best done in your book.
- Go to the online learning environment for some useful extras.
- This is how long this practical activity will take.
- This exercise is extra challenging.

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What is biology?

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Plants and animals

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Practical activities

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TO FINISH

Summary
Diagnostic test



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Learning how to do research
Practical activities

TO FINISH

Summary
Diagnostic test



What is biology?

BIOLOGY

Maybe a bar of chocolate will cost ten euros in ten years' time – who knows? That's because cocoa trees are under threat from viruses that are spread by lice. Global warming and drought won't make things any better: they are leaving fewer places where cocoa trees can grow. In turn, that has consequences for the income of cocoa farmers. Biologists are trying to find solutions for this problem, in the same way that they have been looking for answers to all kinds of issues for thousands of years. Back in the fourth century BCE, Aristotle was wondering why people get acne on their faces above all. He also examined an octopus, looking for the reproductive organs (which he found). The scientists Watson and Crick wondered about the structure of DNA, which they worked out in 1953. One of the big questions now is how we can defeat cancer.

fig. 1 A chocolate bar.



fig. 2 Cocoa beans.



WHAT DOES BIOLOGY TEACH YOU ABOUT?

Over the coming year, the biology course will tell you what biologists have discovered. You will be looking at the themes of **Plants and animals, Organs and cells, Classification, Support and locomotion, Senses, behaviour and coordination** and **Reproduction in plants and animals**. These themes will teach you how fungi make beer, why you might get sick, why lemons turn yellow, what a paramecium is, how you can get 'game boy back', what mucus looks like under the microscope, that we all have DNA – and lots more besides.

You may already have realised that biology courses aren't only theory: you will be doing practical activities yourself as well. You will practice the skills that you need for doing research. You will examine cells from your own body and from other organisms under the microscope. You will learn to look carefully at organisms by drawing an apple. You will culture moulds yourself (pong alert!) and keep mealworms. You will record the growth of a brown bean plant as a graph. You will take a scalpel to a mussel to examine the organs. In short, you will be studying life.

ALL AROUND YOU

Knowing about biology lets you answer biological questions such as how we can generate energy sustainably and how we can produce enough food that nobody goes hungry. People also use knowledge from biology in architecture and technology.

In Zimbabwe, the architect Mick Pearce drew inspiration from a termite mound when he was designing a block of flats. The temperature inside a termite mound always stays the same, even when it's very hot during the day or very cold at night. The architect copied the ventilation system that achieves that in his block of flats.

fig. 3 Block of flats designed using insights from biology.



1 a termite mound



2 Eastgate Building in Harare, Zimbabwe

If you look carefully, biology is everywhere. Studying nature lets you understand the world better and maybe even find solutions for the world's problems. Welcome to biology!

1

Figure 4 shows you a puzzle print by Jan van Haasteren. He makes large drawings in which all kinds of things are happening. Biology is everywhere – so it's in the print too, of course.

Look at the picture and find as many plants and animals as possible, as well as things that are made from plants or animals.

fig. 4



2

Biology is about life.

How can you prove that you are alive? Think about your answer and see if you can come up with evidence that convinces the person sitting next to you.

3

Take a look in your lunchbox.

- a What's in it?
- b What plants or animals are these food items made from?

4

Studying yourself.

- a Measure your heart rate (the number of beats per minute, bpm).
- b What method did you use for measuring your heart rate?

Biologists look for answers to questions.

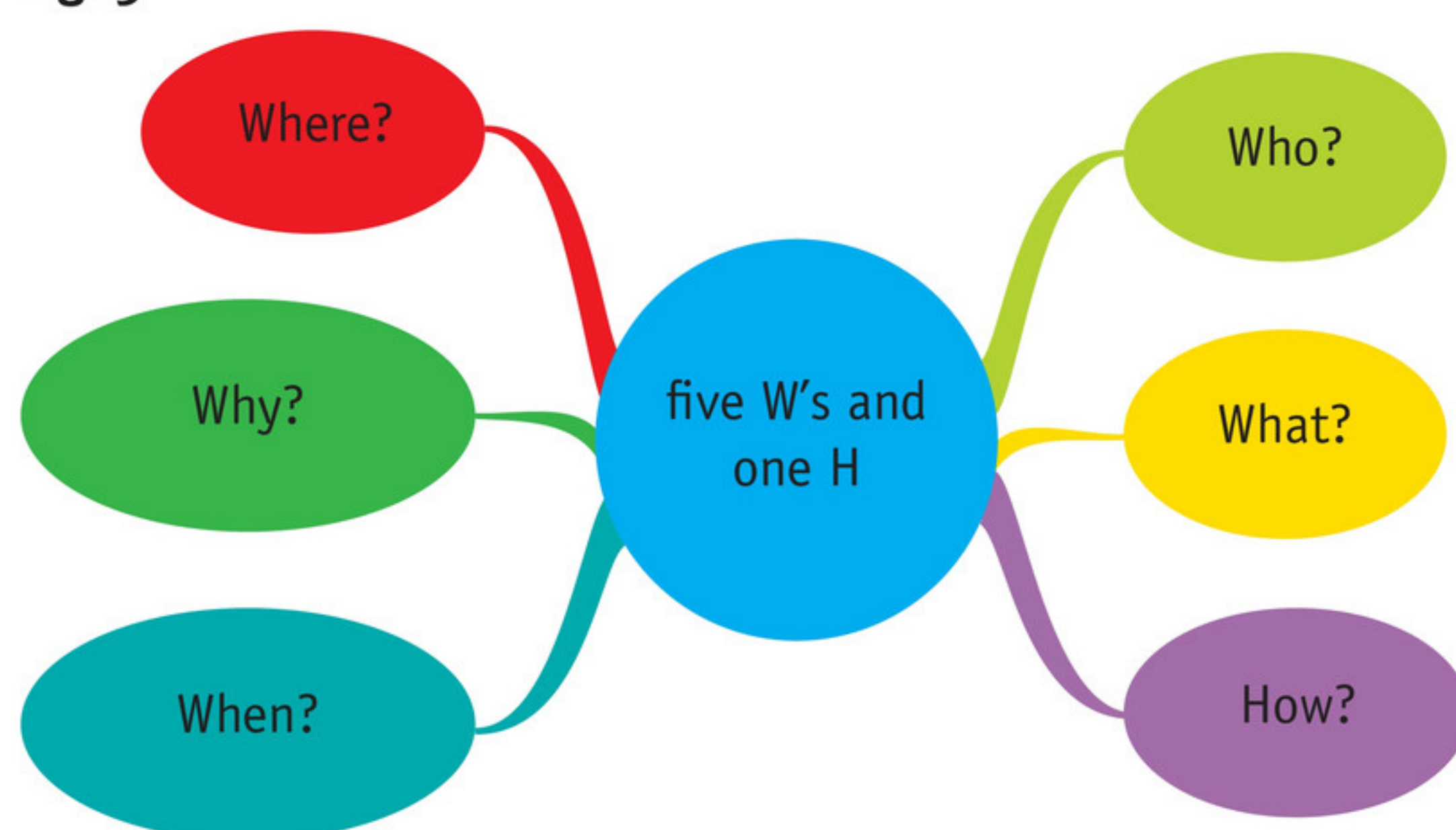
a Which of these questions do you think biology could help answer?

- ☐ A How do game developers make their games as addictive as possible?
- ☐ B How does a paracetamol tablet know where the pain is?
- ☐ C Can animals have allergies?
- ☐ D Why does it hurt when you touch a stinging nettle?
- ☐ E Why haven't we been able to eliminate the common cold virus?
- ☐ F Why do mosquitoes mostly bite at night?
- ☐ G Why do people get carsick?
- ☐ H What exactly is gluten?

b Figure 5 shows you six words that can be used to ask a question.

For each of those words, think up a question about biology that you would like to know the answer to.

fig. 5



6

People in the past have also been inspired by topics from biology. You can see that in the painting in figure 6, which is more than four hundred years old.

Take a close look at it.

- a** Find as many living creatures as possible in the painting.
- b** Which of those living creatures have you ever seen in real life?
- c** Some of the animals in the painting look very different than in real life.
Why might that be the case?

fig. 6 *Adam and Eve in the Garden of Eden* (Jan Brueghel the Elder, 1615).



7

Go outside and draw the first plant or animal that you see. That can include small plants or animals too!

8

You are going to do an experiment. You will be working in pairs. You will need a stopwatch to do this experiment.

- a** Measure how long your classmate can keep their eyes open without blinking.
- b** Make a table containing the results for all the pupils in the class. It will need three columns: the name, the time and whether they are a boy or a girl.
Work out the average (mean) for the whole class.
- c** Do the numbers show any difference between the times for boys and girls?

9

The aircraft manufacturer Airbus designed a special plane for transporting fuselage parts between its production sites in Toulouse and Hamburg. It is known as the Beluga (see figure 7) and it came into service in 2019.

- a** What animal, other than a bird, was used as the inspiration for the shape of this aircraft?
- b** The aircraft has a streamlined shape.
What is the function of that shape when it is flying?
 - ☐ A To let it move through the air with less resistance.
 - ☐ B To let it carry as much cargo as possible.
- c** What other animals could you use as inspiration for aircraft shapes?
Give an example and explain why you think it would be a good inspiration to use.

fig. 7 The Airbus Beluga.



1

Plants and animals

In biology, you study all living things. You learn what living things do to stay alive, such as feeding and defending themselves. Many living things have adaptations to their way of life.

BASICS

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1 Organisms

LEARNING OBJECTIVES

- 1.1.1 You can explain what an organism is.
- 1.1.2 You can list the seven life processes.
- 1.1.3 You can distinguish between things that are living, dead or non-living (never alive).

- Learning how to do research 1
- Practical activity 1

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	1.1.1	1.1.2	1.1.3
Remembering	1a	2	
Understanding	1bc, 5	3, 5	4, 5
Using	10b	7a, 8, 10ac	6
Analysing		7bc, 9	7bc

The Greek word for life is *bios* and *logos* means a study or science. Together these two words make 'biology': the study of life.

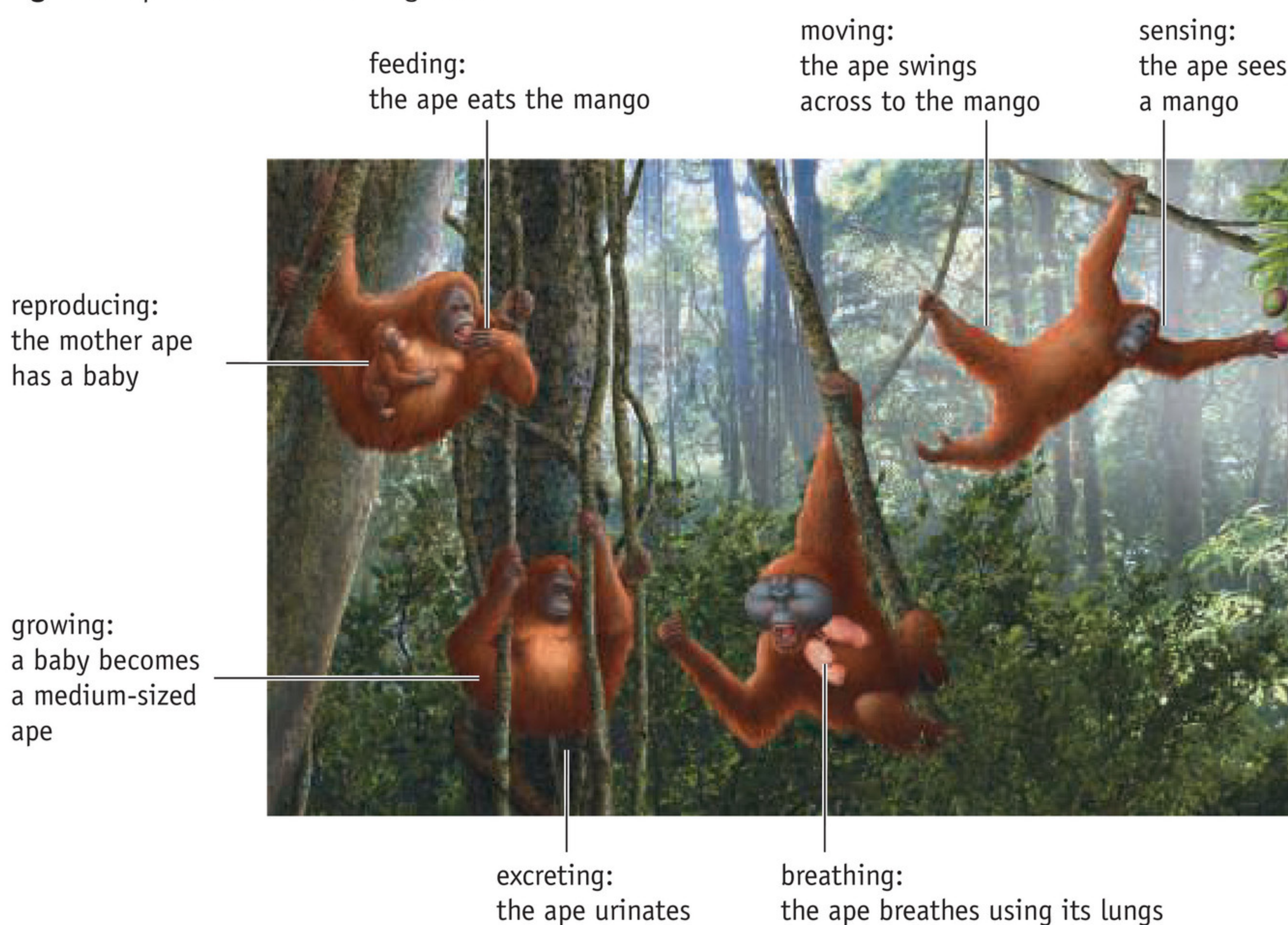
LIVING CREATURES

Biology is about organisms. An **organism** is a living creature. Humans, animals and plants are organisms, just like bacteria and fungi are. All organisms have **life processes**. The life processes tell you whether something is **living** and therefore an organism. A stone does not have life processes, so a stone is not an organism.

You can see the life processes of an orang-utan in figure 1. The seven life processes are:

- breathing
- feeding
- excreting
- sensing
- moving
- reproducing
- growing

fig. 1 Life processes in an orang-utan.



UPTAKE AND ELIMINATION OF SUBSTANCES

All organisms breathe. Breathing is a life process. Besides breathing, most organisms must also eat and drink. This is called ‘feeding’ in biology. Substances enter your body when you eat, drink or breathe – water and oxygen, for instance. Your body uses these substances to help it stay alive.

Your body also gets rid of waste substances into the surroundings, for instance when you exhale or urinate. Releasing substances into the surroundings is called ‘excreting’. Breathing, feeding and excreting are the three life processes that are related to the uptake and elimination of substances.

REACTING TO THE ENVIRONMENT

Most organisms can sense things in their surroundings. A rabbit, for example, can see and hear threats. This lets it hop back quickly to its burrow. Many organisms respond to their surroundings by moving. Sensing and moving are the two life processes related to responding to the environment.

SURVIVAL

Organisms need offspring. Rabbits can reproduce very quickly. They can produce young several times a year. The young then grow. When they are mature, they also start reproducing. Offspring ensure that a group of organisms continues to exist. Reproducing and growing are the two life processes related to the survival of a species.

LIVING, DEAD AND NON-LIVING

When the life processes of an organism have stopped, it is **dead**. Some things in nature were never alive. These things are called **non-living**. Rocks, air and water are all non-living, for example. The non-living aspects of nature often have a huge influence on living nature (see figure 2).

fig. 2 Alive – dead – non-living.



KNOWLEDGE

1

- Biology is about organisms.
- a What is an organism?
 - b How can you tell whether something is an organism?
 - c Give five examples of organisms.

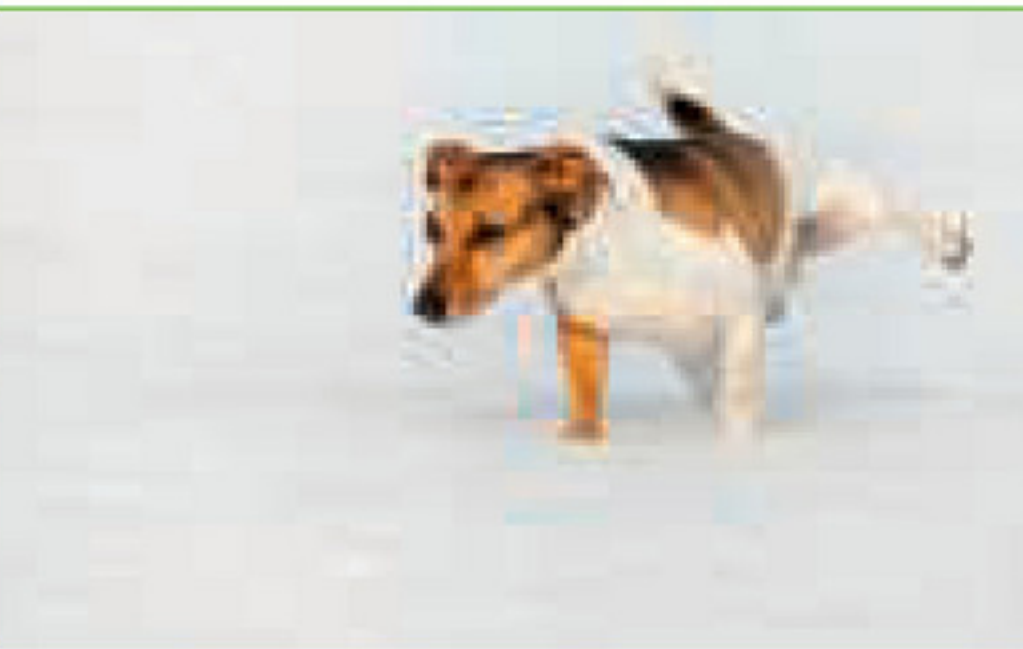
2

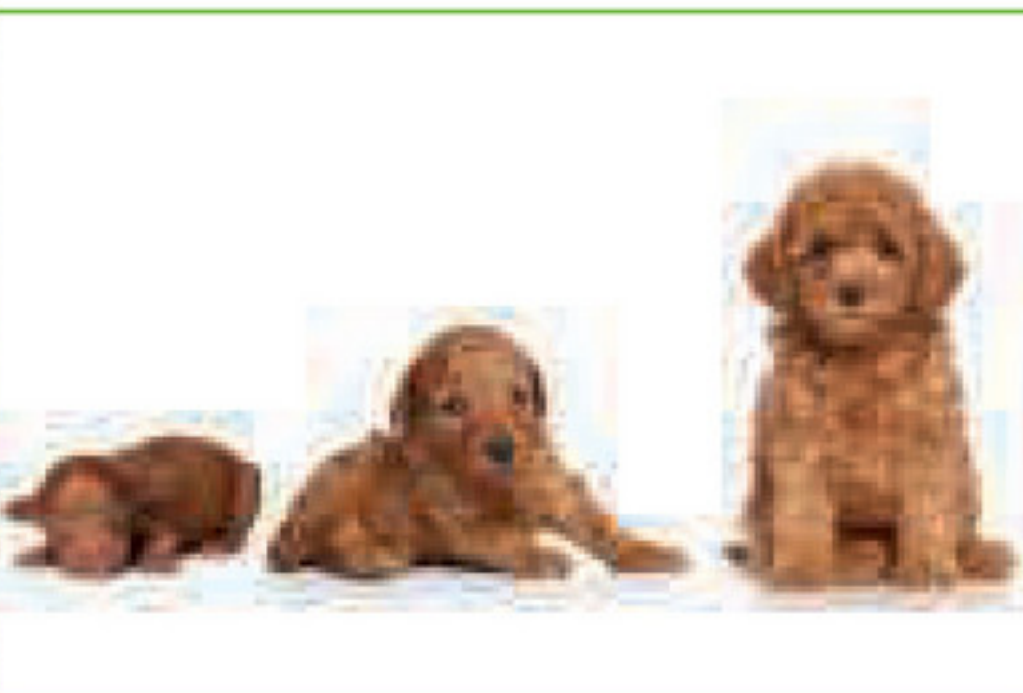
- Organisms have life processes.
- a Which three life processes involve taking in and eliminating substances?
breathing / moving / growing / excreting / feeding / reproducing / sensing
 - b Which two life processes involve reacting to the environment?
breathing / moving / growing / excreting / feeding / reproducing / sensing
 - c Which two life processes are part of survival?
breathing / moving / growing / excreting / feeding / reproducing / sensing

3

- Figure 3 shows seven photographs of dogs.
- a Put the correct life process above each photograph. Use each life process only once.
 - b Write in the descriptions of the life processes under each group.

fig. 3 Life processes in a dog.

		
<i>responding to the surroundings / taking in and getting rid of substances / offspring and survival</i>		

			
<i>responding to the surroundings / taking in and getting rid of substances / offspring and survival</i>		<i>responding to the surroundings / taking in and getting rid of substances / offspring and survival</i>	

4

What is the difference between non-living and dead?

5

Summary

Make a summary of this Basics section. Do that by answering the questions.

- What is biology about?
- What is an organism?
- What are the seven life processes?
- Wat do living, dead and non-living mean?

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INSIGHT

6

- a** For each numbered item in figure 4, state whether it is living, dead or non-living.
b Is a wooden plank dead or non-living? Explain your answer.

fig. 4 Alive, dead or non-living?



7

Three of the life processes are feeding, reproducing and growing.

- a** For each process, state how you can observe it in a plant in the ground.
b Some people claim that a cut flower in a vase is alive. Others would say that a flower in a vase is dead.
 Give an argument for saying that the flower is alive.
c Give an argument for saying that the flower is dead.

8

- a** Which life process is sweating an example of? Explain your answer.
b Which life processes can you see in a teacher while they are teaching?

+ 9

A plant on the windowsill turns its leaves towards the light.
Which two life processes can you see from this? Explain your answer.

HOW IT FITS TOGETHER the living world

THE SENSES OF A FOX

The noise made by an approaching walker makes a fox scamper away. It runs for quite a distance, away from the danger. Near a tree at the edge of the woods, the fox catches the scent of a rabbit. It immediately starts walking more slowly. The fox sees three rabbits in a clearing. The animal creeps slowly towards the nearest rabbit. The fox can feel the surrounding tall grass against its whiskers, telling it that it is hidden from view. The fox jumps out of the tall grass and pounces on its prey, killing the rabbit with one bite and then eating the meat.

fig. 5 A fox.



10

Read the text ‘The senses of a fox’.

- a The fox senses its surroundings in four ways.
How? For each way, say what the fox senses.

- 1
- 2
- 3
- 4

- b Various organisms are mentioned in the text.
Highlight the organisms in the text.
- c Which three life processes can be found in the text?
breathing / feeding / excreting / sensing / moving / reproducing / growing

 Go to the *Flash cards* and the *Test yourself* section.

2 Growth and development

LEARNING OBJECTIVES

- 1.2.4 You can describe what growth and development are.

1.2.5 You can list the parts of a seed and their functions.

1.2.6 You can describe the lifecycle of a seed plant.
- Learning how to do research 2

► Practical activities 2, 3, 4 and 5

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	1.2.4	1.2.5	1.2.6
Remembering	1ab	2a	3
Understanding	1c, 4	2b, 4	4
Using	5, 7	9a	6, 9ad
Analysing	9c	8, 9bce	8, 9bce

A seedling can grow from a seed. The small plant keeps growing bigger. The shape of the plant also changes as it grows.

GROWTH

Plants, animals and people all grow, just like other organisms. You too are larger and heavier than when you were a baby. Growth happens when an organism gets larger and heavier.

Figure 1 gives examples of growth in a plant, an animal and a fungus.

fig. 1 Growth.



A SEED

Most plants grow from seeds. One example of a seed is a brown bean (see figure 2). There is a tough brown skin on the outside of a brown bean, its seed coat. The seed coat protects the seed. The white spot on a brown bean is called the hilum. The hilum is where the seed was attached to the plant.

Figure 2 also shows a dark heart-shaped bulge under the hilum. On the other side of the hilum, there is a very small hole in the seed coat. This pore is called the micropyle. A seed can absorb water quickly through the opening. Water is needed for the germination. The seed contains a plant embryo, the start of a new plant. Germination starts when the seed absorbs water. During germination, the plant embryo grows into a seedling (see figure 3). The first leaves that appear above the ground are called the seed leaves. They are the two halves of the seed. Nutrients (reserves of food) are stored in the seed leaves. During germination, the seedling uses the nutrients from the seed leaves.

fig. 2 A brown bean (a seed).

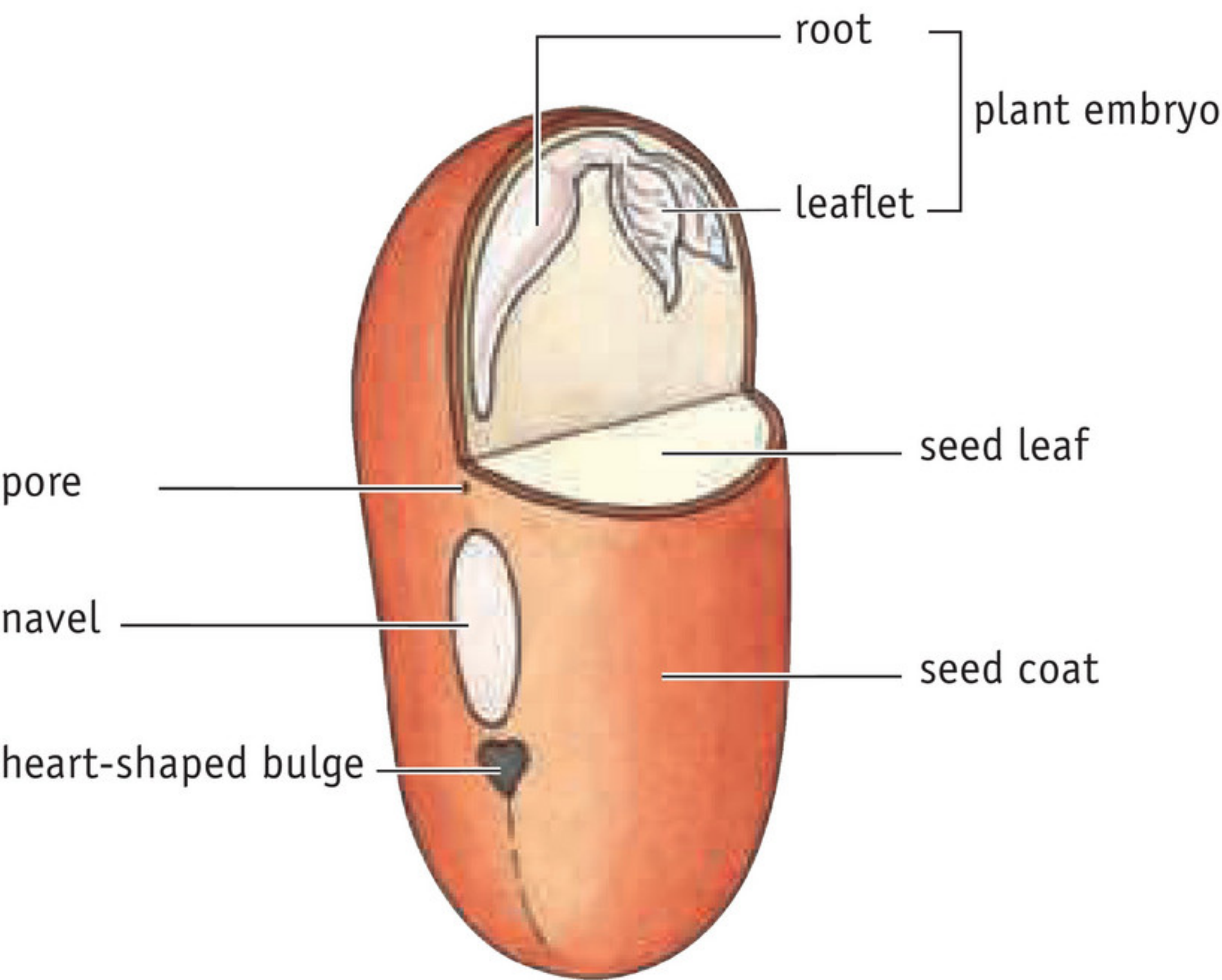
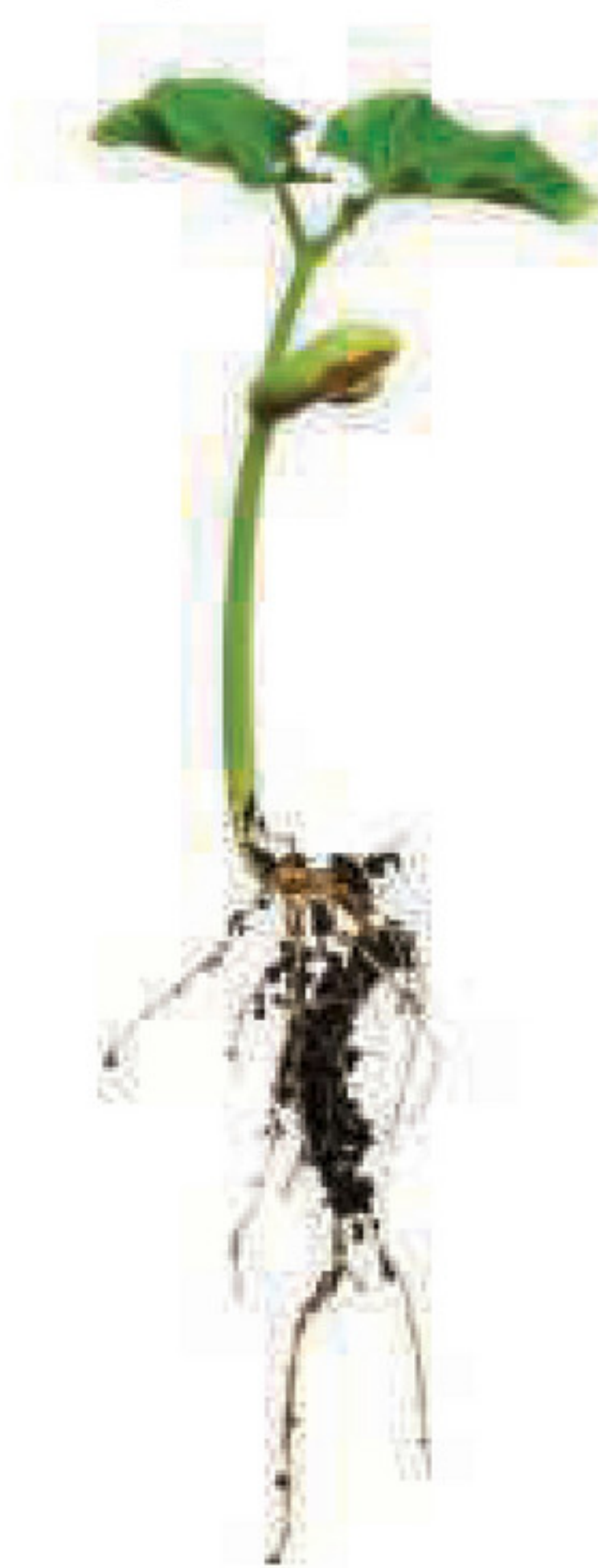


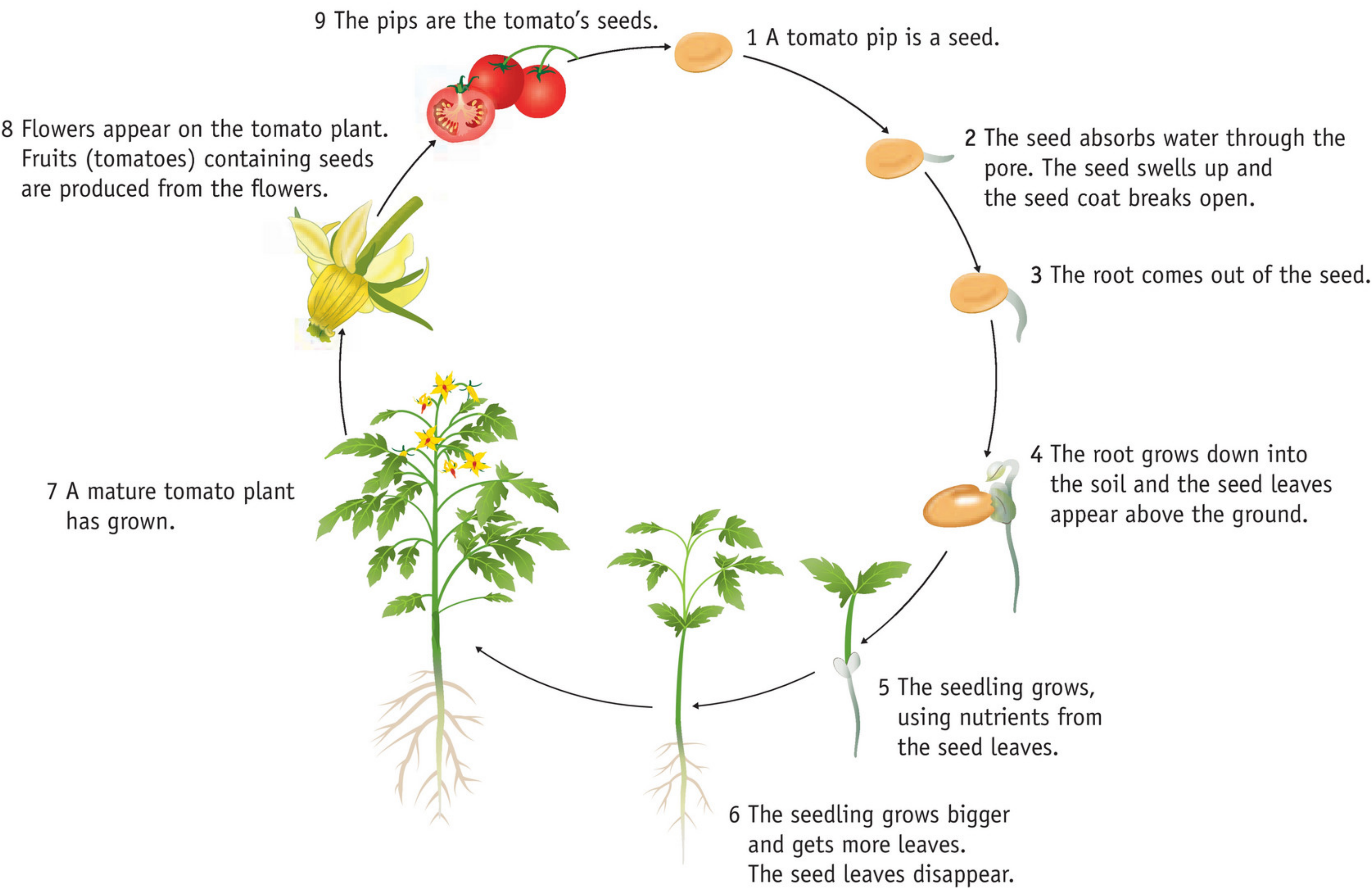
fig. 3 Seedling of a brown bean.



LIFECYCLE

Figure 4 shows you how a tomato plant grows from a seed. The tomato plant grows more leaves. Finally, flowers appear on the plant from which the fruits grow (the tomatoes). These fruits have seeds, which can grow into new tomato plants. The development of a seed into a plant and finally into a fruit (with seeds) is called the **lifecycle** of the plant. A cycle is a process that keeps repeating. The end of one cycle is the start of the next cycle.

fig. 4 Lifecycle of a tomato plant.



DEVELOPMENT

The tomato plant not only grows bigger and heavier but its shape changes too. The roots branch off and new parts appear, such as stems and leaves. Changes in the structure of an organism are called **development**. Development lets the parts of the organism work better. Example: because the roots of the plant branch off, they can absorb water from the soil better.

ANIMALS

Growth and development occur in animals too. Figure 5 shows you a penguin egg, the chick and the adult animal. A great deal of development takes place inside the egg. The chick is already well developed by the time it hatches. In other words, the body structure of the chick is already similar to that of the adult penguin. You can see that the chick still has a lot of growing to do: it becomes bigger and heavier.

fig. 5 Growth and development in a penguin.



KNOWLEDGE

1

- Organisms grow and develop.
- a What is growth?
 - b What is development?
 - c Figure 4 shows the lifecycle of the tomato plant. This lifecycle can be divided into three stages:
 - germination (steps 2 and 3)
 - seedling (steps 4, 5 and 6)
 - mature plant (steps 7, 8 and 9)
- Complete the table. Use each stage once.

What is happening?	Stage
Largely growth	
Largely development	
Both	

2

Four parts of a seed are the plant embryo, micropyle, hilum and seed leaves.

a Which part of the seed is being described?

- 1 The seed was attached to the parent plant by the
- 2 The seed absorbs water through the pore (the).
- 3 When a seed germinates, a seedling starts to grow from the
- 4 The first leaves that appear above the ground are called the

b The seed leaves wither away as the seedling grows.
Explain why.

3

You can divide the lifecycle of a plant into stages.
Put the steps of the lifecycle of a plant in the correct order. Step 1 has been given.

- There is now a mature plant.
- The root comes out of the seed.
- The seedling grows and uses the nutrients from the seed leaves to do so.
- 1 There is a seed.
- The seed absorbs water through the pore.
- The root grows down into the soil and the seed leaves appear above the ground.
- The seedling grows larger and gets more leaves. The seed leaves disappear.
- Flowers appear on the plant.
- The seed swells up and the seed coat breaks open.
- Fruits containing seeds are produced from the flowers.

4

Summary

Make a summary of this Basics section. Do that by answering the questions.

- What is the difference between growth and development?
- What are the parts of a seed?
- What are the functions of the parts of a seed?
- What are the stages in the lifecycle of a seed plant?

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INSIGHT

5

Examples of growth and development in rabbits, dogs and cows are given below.

- a

Are they examples of growth or development?

1

The eyes of a new-born rabbit open.

growth / development

2

The body length of a calf increases.

growth / development

3

A dog’s teeth and molars are formed.

growth / development

4

The weight of a calf increases.

growth / development

5

Fur appears on young rabbits.

growth / development

6

Milk-producing vesicles appear in cows’ udders.

growth / development
- b

Development let the parts of the organism work better. Example: a dog can eat solid food because it developed teeth.

Think of an example of development in an animal that lets it function better.

6

Cucumbers are the fruits of the cucumber plant.
Read the ‘Baby vegetables’ text.
Describe and/or draw the lifecycle of a baby cucumber plant.

fig. 6

Baby vegetables

Children are especially fond of them: mini vegetables, also known as baby vegetables or snack veg. That doesn’t mean they are special vegetables for babies: they are smaller variants of normal vegetables. As well as small tomatoes and cucumbers, there are also mini variants of maize, artichokes, cauliflowers, pak choi and bell peppers. The plants that the mini veg grow on look the same as the “normal” plants. If you look carefully, though, you can sometimes see small differences. Mini cucumbers, for example, produce lots of fruits on a single plant.



7

Figure 4 shows you how a tomato plant grows from a seed.
Say whether each sentence is an example of growth or development.

- 1

The leaves get bigger.

growth / development
- 2

The stem gets longer.

growth / development
- 3

The roots branch off.

growth / development
- 4

Leaves appear.

growth / development
- 5

Stems appear.

growth / development
- 6

The plant has become bigger.

growth / development
- 7

The plant has become heavier.

growth / development

+ 8

Read the text “Ancient seeds germinated”.

- a Explain how seeds that are centuries old can still be undamaged.
- b Explain how seeds can remain in the soil for centuries without germinating.

fig. 7

Ancient seeds germinated

Some seeds found during archaeological excavations are still alive after hundreds or even thousands of years. Flowers, trees and vegetables grow from them that had long since become extinct. The oldest known seeds from which a plant has been grown again are 30,000 years old. They were found in squirrel burrows in North-eastern Siberia. At that time, mammoths and woolly rhinoceroses still walked around the grassy tundra.

There are also much more recent examples. Scientists in Israel managed to germinate the pits of date palms that disappeared in around 200 CE. That the pit was still alive after such a long time is partly due to the dry environment.

After: “New life from ancient seeds”, *New Scientist*, 7 December 2015.

HOW IT FITS TOGETHER science

PLANTS ARE URBANISING

Some plants have adapted very cleverly to their urban environments. A textbook example is hawksbeard (*Crepis sancta*), a plant with yellow flowers resembling a dandelion.

Hawksbeard (see figure 8) cannot yet be found in the Netherlands, but the species has migrated from southern France up as far as Belgium.

Hawksbeard blooms every year in April and May. The flowers produce two types of fruits: small, light fruits attached to fluff, and larger, heavy fruits without the fluff. Each fruit has a single seed. Both types of fruits appear in the same flower, but the ratio varies from one plant to the next. French researchers compared plants in cities against plants in an agricultural area 30 km away. They discovered that the urban plants had a lot fewer fluffy seeds than the plants in the rural areas. Their research showed that this change had only occurred in the last five to twelve generations of plants.

After: “Evolution is on the street”, *www.bionieuws.nl*, 17 February 2016.

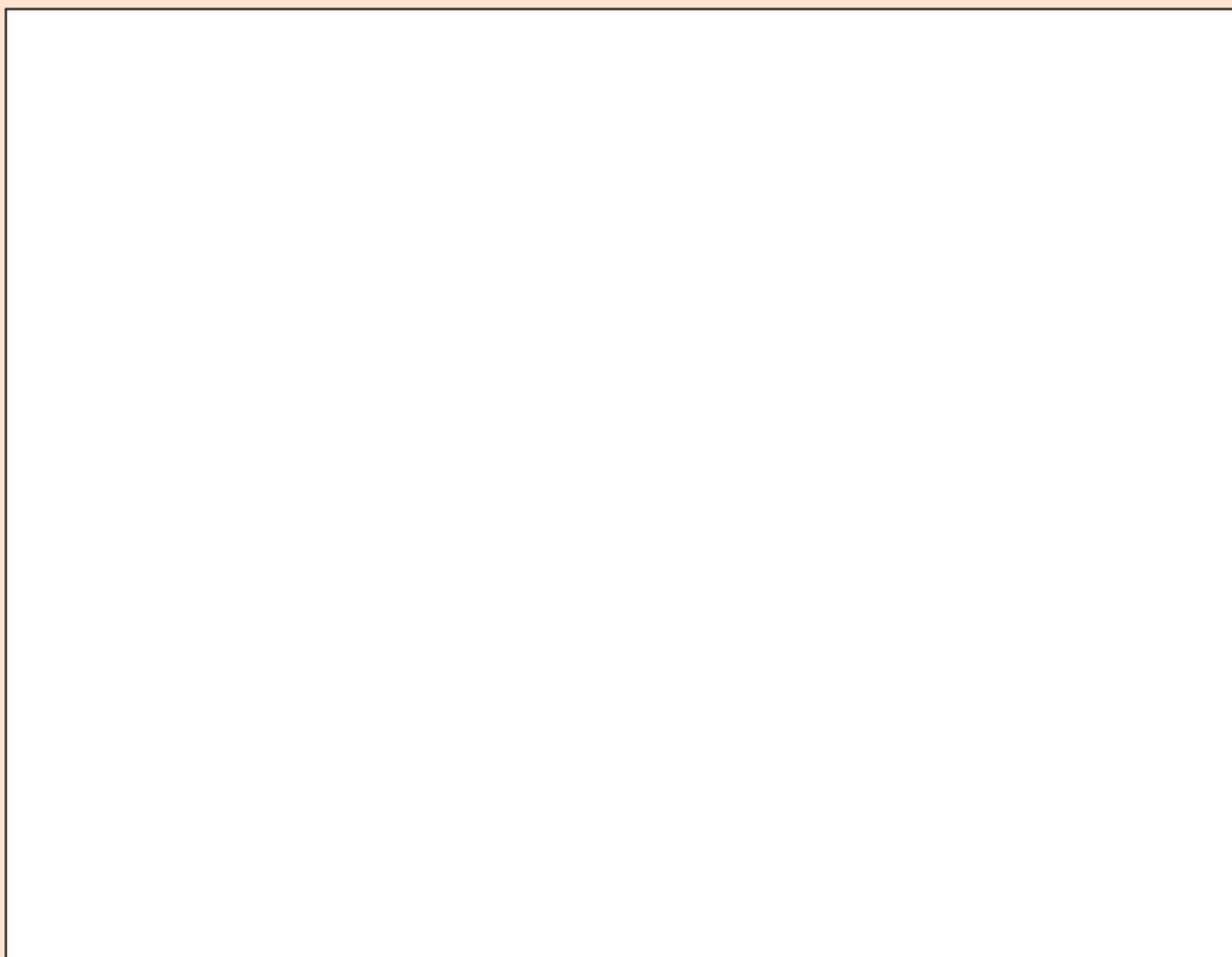
fig. 8 Hawksbeard.



9

Read the text “Plants in the city are urbanising”.

- a** Hawksbeard has two types of fruits. Each fruit has a single seed.
Make a drawing of both types of fruits. Add the labels to the parts. Also show where the seed is.



- b** The light fruits have fluff.
What is the fluff for?
- c** The urban plants have more heavy fruits without fluff. These fruits fall straight down.
Explain why this is an advantage in a city.
- d** The changes in hawksbeard occurred in five to twelve plant generations. Each generation starts with the germination of a seed from a plant from the previous generation.
How many years are there in twelve generations? Explain your answer.
- e** Empty pieces of land in southern French towns, where houses have been demolished, quickly get overrun by hawksbeard.
Which type of fruit did the first plants on such a piece of land come from? Explain your answer.

 Go to the *Flash cards* and the *Test yourself* section.

3Metamorphosis

LEARNING OBJECTIVES

- 1.3.7 You can describe what metamorphosis is.
- 1.3.8 You can describe the lifecycles of cabbage white and of a frog.
- Practical activity 6

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	1.3.7	1.3.8
Remembering	1ab	2a, 4
Understanding	1c, 5	2b, 3, 5
Using	6b, 10abc	6ab, 7, 8a
Analysing	10d	8b, 9

Children look a lot like adults. They have arms, legs, eyes, ears and a mouth. Not all animals young look like their parents.

YOUNG AND ADULT ANIMALS

Not only plants have lifecycles: so do animals. In some animals, the young don't look at all like the adult animals: take a ladybird, for example (see figure 1). A ladybird starts its lifecycle as an egg. A **larva** comes out of the egg. A larva looks different from an adult insect. The larva of a ladybird does not have wings and eats different food than an adult ladybird. Before it becomes an adult, the larva undergoes a transformation or **metamorphosis**. During the metamorphosis, the insect's body structure and the way it lives change.

fig. 1 A ladybird.



1 larva



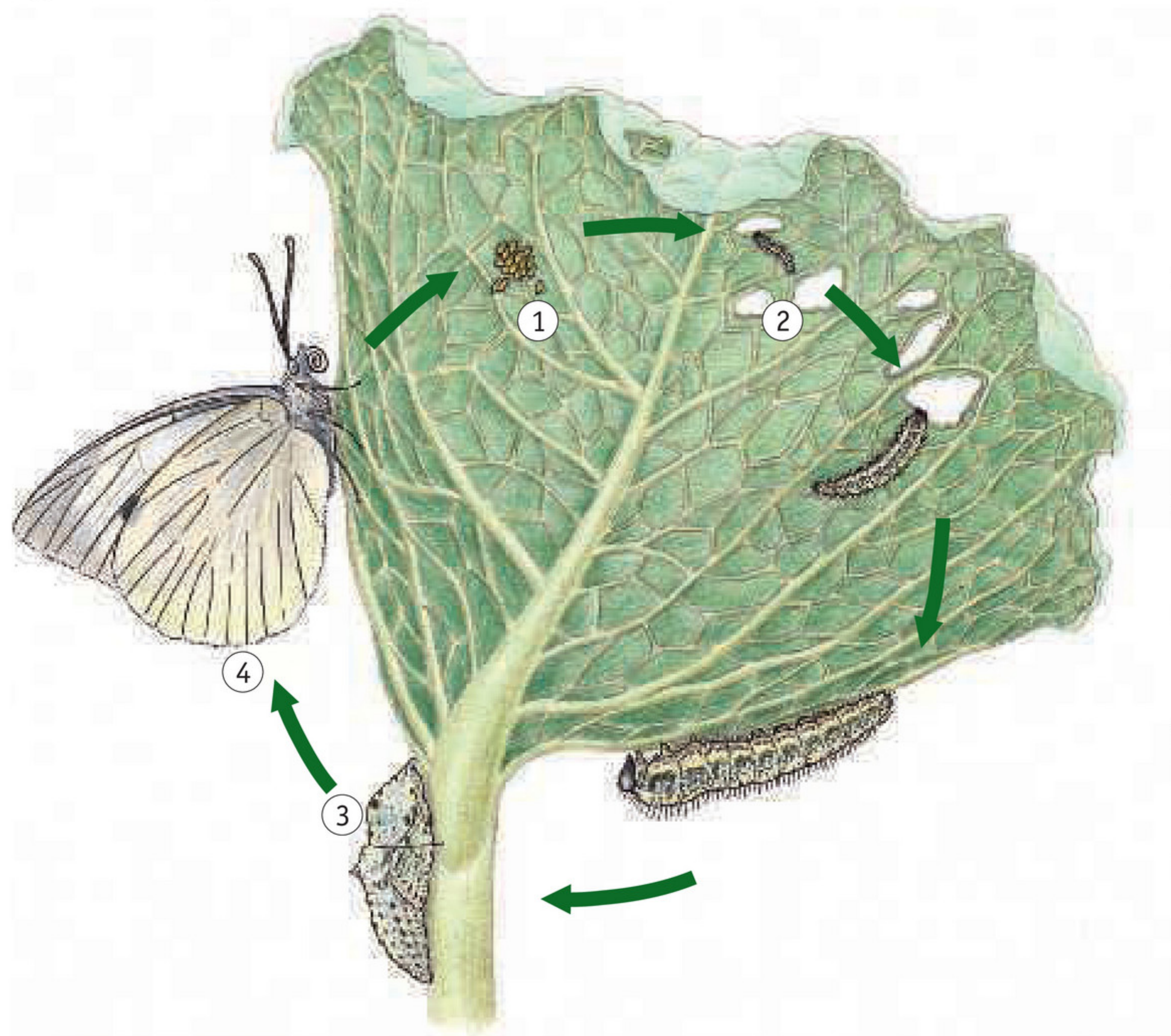
2 adult animal

BUTTERFLIES

Butterflies such as the cabbage white also undergo a metamorphosis. In their lifecycle, butterflies go through four **stages** of life, with a metamorphosis (see figure 2):

- egg
- larva
- pupa
- imago

These four stages can also be seen in other insects such as beetles, bees, flies and wasps.

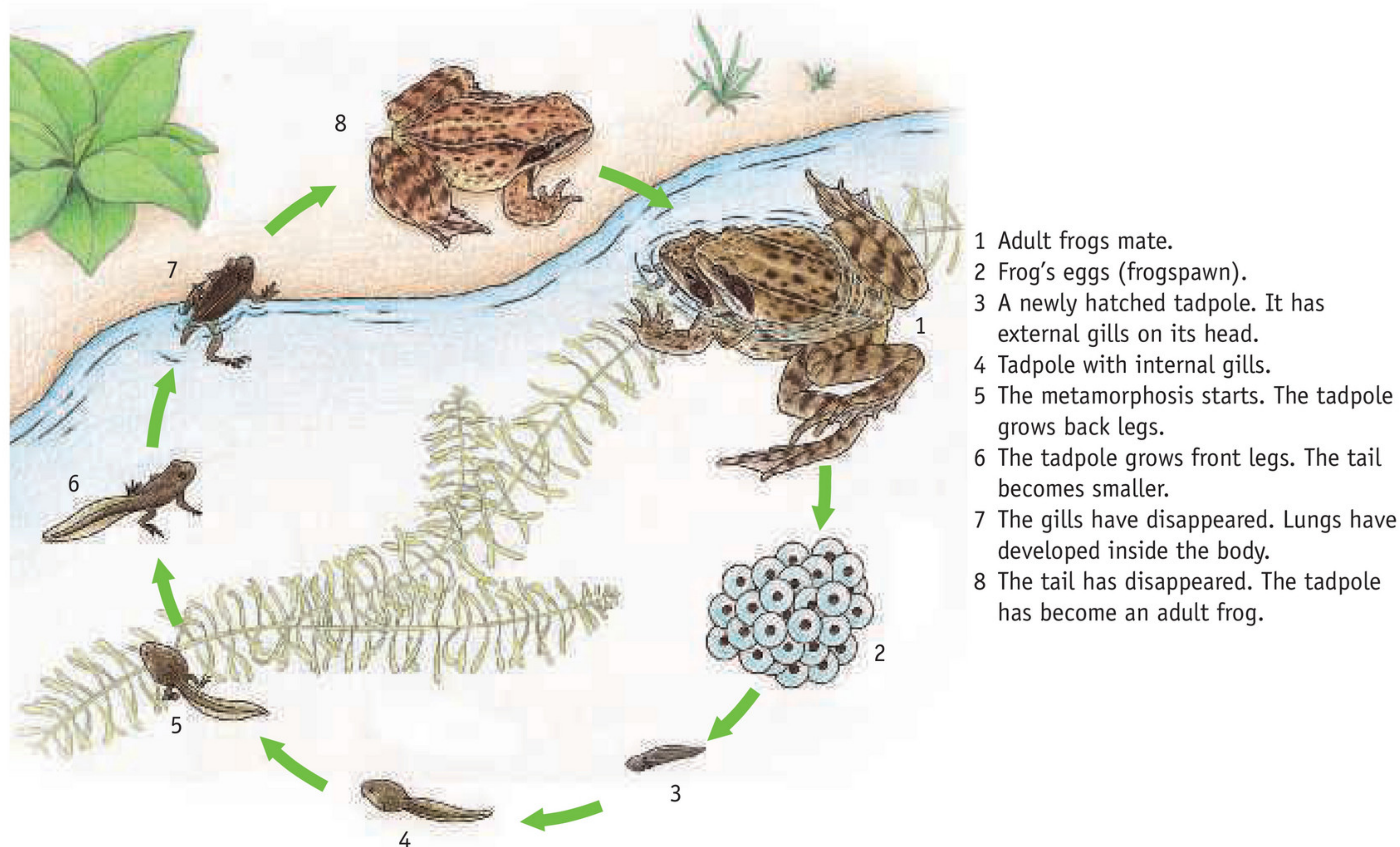
fig. 2 The lifecycle of a cabbage white.

- 1 A cabbage white lays eggs on cabbage leaves.
- 2 A small caterpillar comes out of the egg. The caterpillar eats a lot. The caterpillar grows fast when it sheds its skin.
- 3 The caterpillar makes a cocoon around itself. The pupa does not eat and it does not grow either. Inside the cocoon, the body of the caterpillar changes into that of a butterfly (metamorphosis).
- 4 The adult stage (imago) of the butterfly comes out of the pupa. A butterfly does not grow. A butterfly is able to reproduce.

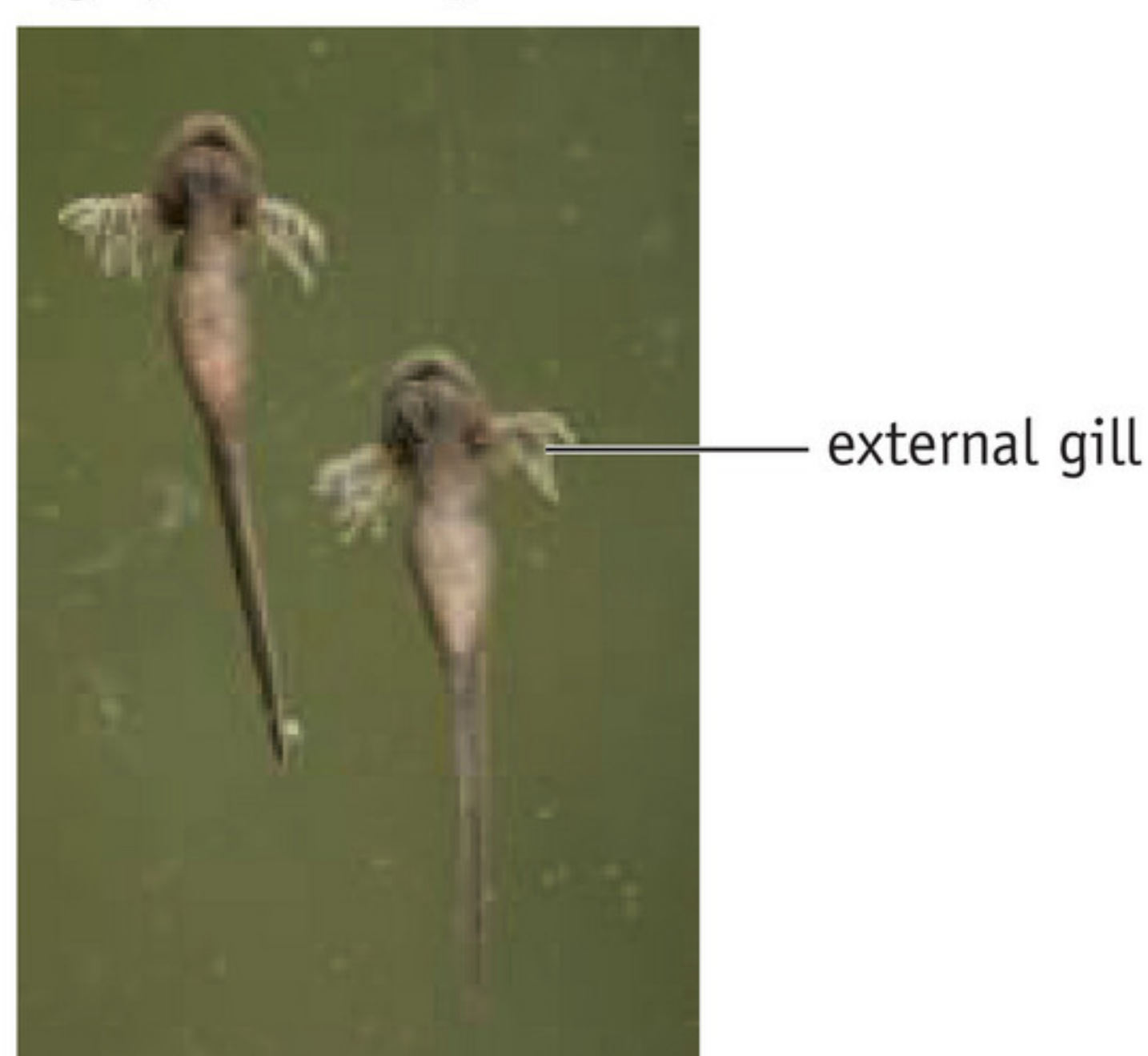
Cabbage whites often lay their eggs on cabbage leaves. After a few warm days, a larva emerges from each egg. The larvae of butterflies and moths are called caterpillars. The caterpillars eat the cabbage leaves, which lets them grow. The caterpillars have tough armour that protects their bodies. This outer armour cannot grow, which is why caterpillars shed their skin several times. When this happens, the hard armour splits open and the caterpillar crawls out of the opening. The caterpillar then produces a new, larger layer of armour. Before the new armour hardens, the caterpillar can grow a lot. After each shedding, the caterpillar goes back to eating. Eventually, the caterpillar looks for a quiet spot. It creates a shell around its body. The casing around it is called a **cocoon**. The caterpillar with the cocoon is called a **pupa**. A pupa (or chrysalis) does not eat and generally does not move either. The metamorphosis takes place in the cocoon. The caterpillar's body undergoes enormous changes. All sorts of new parts appear, such as wings, large eyes, a proboscis (the roll-up tongue) and antennae. After two to three weeks, the pupa breaks open and a mature butterfly emerges. The adult stage is called the **imago**. After a few hours drying off, the butterfly can fly away.

FROGS

Frogs such as the common frog also undergo a metamorphosis. The lifecycle of a common frog is shown in figure 3.

fig. 3 The lifecycle of a common frog.

Common frogs lay their eggs in ponds or ditches. The eggs stick together to make frogspawn. One frog lays one clump of frogspawn. A clump like that can have as many as three thousand eggs. A small larva develops in each egg. When the larva is 'ready', it crawls out of the egg as a tadpole. A tadpole is about 6 mm long. It has feather-like structures on the sides of its head called the external gills (see figure 4). The tadpole uses its gills to get oxygen from the water. It can absorb oxygen from the water through its skin too. A tadpole mostly eats algae.

fig. 4 External gills.

When the tadpole grows more, the external gills disappear. They are replaced by internal gills. Two small back legs can then already be seen. The front legs start to develop after eight to nine weeks. The tail begins to shorten. After twelve to thirteen weeks, the animal looks like a frog but it is only 15 mm long. The small frog starts eating insects. Meanwhile, lungs have developed inside the body and the gills disappear. This means that the frog is now able to live on land. A frog takes up oxygen from the air using its lungs and through its skin.

KNOWLEDGE

1

Some animals undergo a metamorphosis during their lifecycle.

- a What is another word for metamorphosis?
- b Which two aspects of an animal change during metamorphosis?
- c Between which stages in the life of a ladybird does metamorphosis take place?

2

Figure 5 shows you the various stages in the lifecycle of the cabbage white.

- a Write the name of the stage next to each photograph.

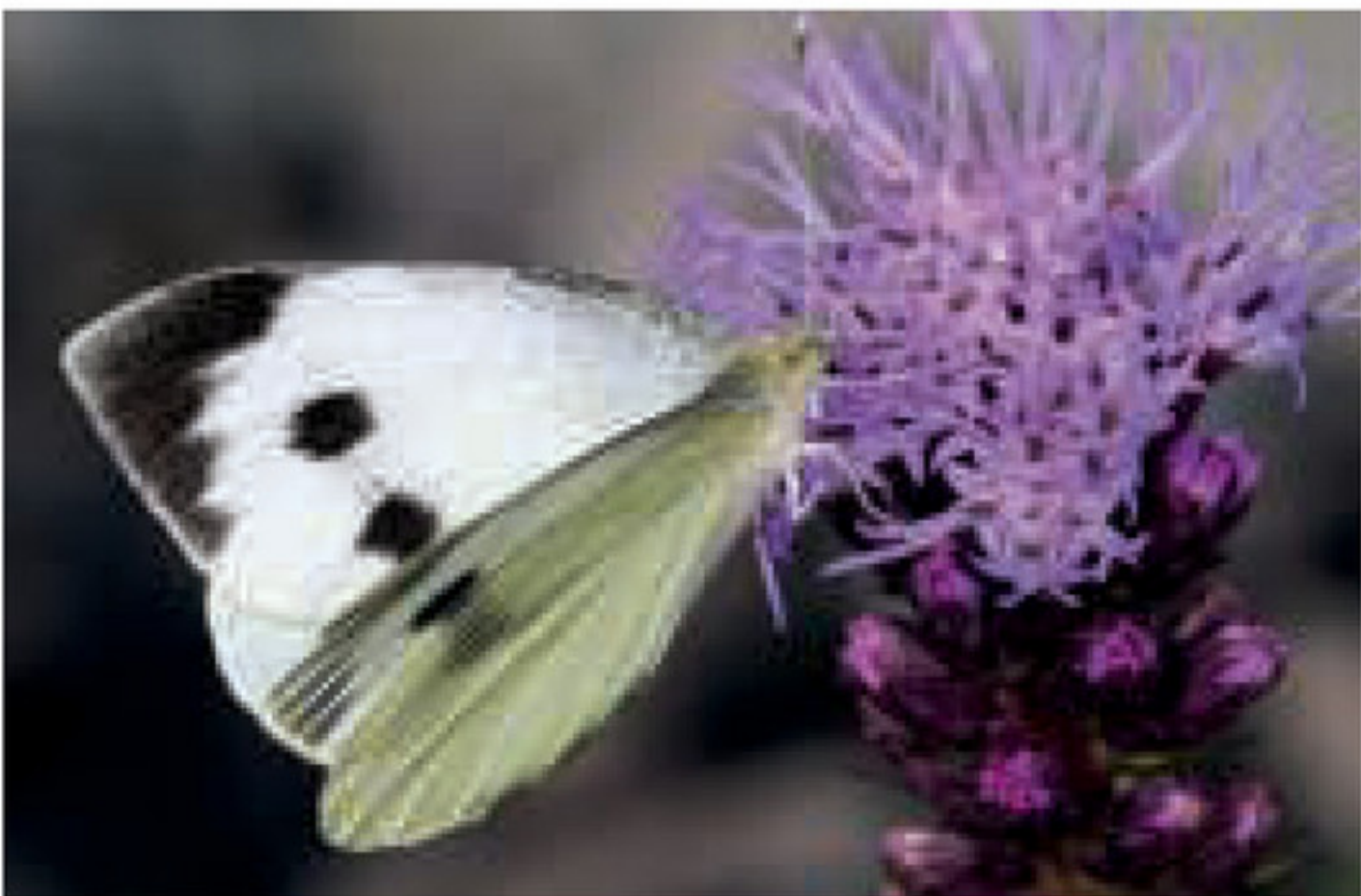
fig. 5 Stages in the lifecycle of a cabbage white.



.....



.....



.....



.....

- b Which stage is each sentence about?

- 1 The stage shedding takes place in:
- 2 The stage a cabbage white reproduces in:
- 3 The stage a cabbage white eats the most in:
- 4 The stage they grow the most in:
- 5 Two stages where they develop lot are:
- 6 The stage the metamorphosis happens in:

egg / larva / pupa / imago
egg / larva / pupa / imago
egg / larva / pupa / imago
egg / larva / pupa / imago
egg / larva / pupa / imago
egg / larva / pupa / imago

3

The lifecycle of a frog consists of seven steps.

- a Put these events in the correct sequence. Step 1 has been given.

- The gills have disappeared. Lungs have developed inside the body.
- Metamorphosis starts. The tadpole grows back legs.
- A newly hatched tadpole. It has external gills on its head.
- 1 A frog lays its eggs (frogspawn) in a pond or ditch.
- The tadpole grows front legs. The tail becomes smaller.
- The tail has disappeared. The tadpole has become an adult frog.
- Tadpole with internal gills.



b Draw the lifecycle of a frog in five steps.

4

Larvae need to feed so that they can grow.

- a** What does a tadpole mostly eat?
- b** What does an adult frog mostly eat?
- c** Which two parts of its body does a tadpole use to get oxygen from the water?
- d** Which part of its body does an adult frog use to get oxygen from the air?

5



Summary

Make a summary of this Basics section. Do that by answering the questions.

- What is metamorphosis?
- What stages are in the lifecycle of a cabbage white?
- What growth and development takes place in these stages?
- What stages make up the lifecycle of a frog?
- What growth and development takes place in these stages?

INSIGHT

6

- a Caterpillars only grow after shedding their skins.
Explain why.
- b Figure 6 shows a graph of the size of a larva.

How many times did this larva shed its skin?

7

Figure 7 shows you a photograph of a cabbage white.
Between which two stages of the cabbage white lifecycle was this photo taken?
egg / larva / pupa / imago

fig. 6 Graph showing the growth of a cabbage white larva.

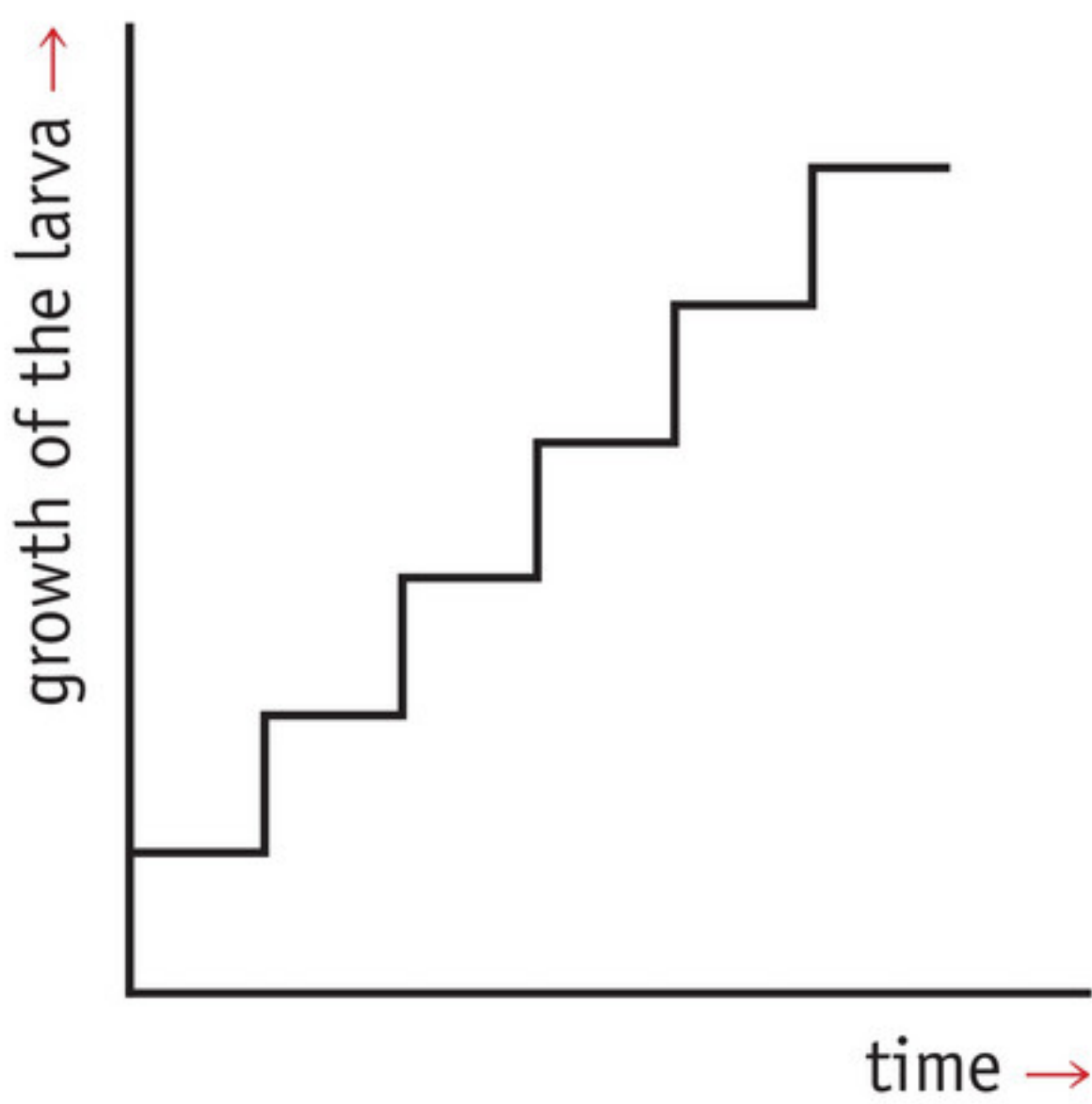


fig. 7 A cabbage white.



8

- A tadpole of eight to nine weeks old is longer than a tadpole of twelve to thirteen weeks old.
- a Why is that?
 - b Which two functions does a tadpole’s tail have?

+ 9

The stages in the lifecycle of the ladybird, the butterfly and the frog are very different.
There are also similarities.
Explain this, giving examples.

HOW IT FITS TOGETHER the living world

ITCHY!

We all know about them, those annoying itchy bugs. Many children get them at least once: head lice. Head lice lay eggs on the hairs on your head. The egg of head louse is called a nit. After six or seven days a nymph, a young louse, crawls out of the nit. A nymph cannot really be called a larva because it already looks a lot like an adult head louse. The nymphs do not pupate but they do shed their skin several times. The nymph grows after each shedding. After shedding around three times in ten days, the louse is an adult animal (imago). Head lice live off blood that they suck from the skin.

Figure 8 is a microscope photo of a head louse on a hair.

fig. 8 Head louse.



10

Read the “Itchy!” text.

- a** Can you say head lice undergo a metamorphosis? Explain your answer.
- b** Which three phases are there in the lifecycle of the head louse?
- c** Head lice used to be very common. As a result, people were often itchy. The itching is the result of an allergic reaction to head louse saliva. That saliva ends up in your body when the louse sucks blood.
In Dutch, there is a phrase that translates as, “It’s itching like nits.” Explain why this saying doesn’t really make sense.
- d** Biologist and writer Midas Dekkers wrote a book entitled *The larva, about children and metamorphosis*.
Explain why you cannot use the term ‘larva’ for a child.

 Go to the *Flash cards* and the *Test yourself* section.

4 Humans

LEARNING OBJECTIVES

- 1.4.9 You can describe various types of development in humans.

1.4.10 You can list the stages of life of humans with the ages and characteristics.
- Learning how to do research 3

► Practical activity 7

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	1.4.9	1.4.10
Remembering	1	2, 4a
Understanding	5abc, 6	3, 4bc, 5a, 6
Using	7, 8bc, 9, 10ab	8a
Analysing	10cd	10d

As you grow and develop, changes also take place in your body. Things go especially quickly between ages 12 and 16. This time is referred to as puberty.

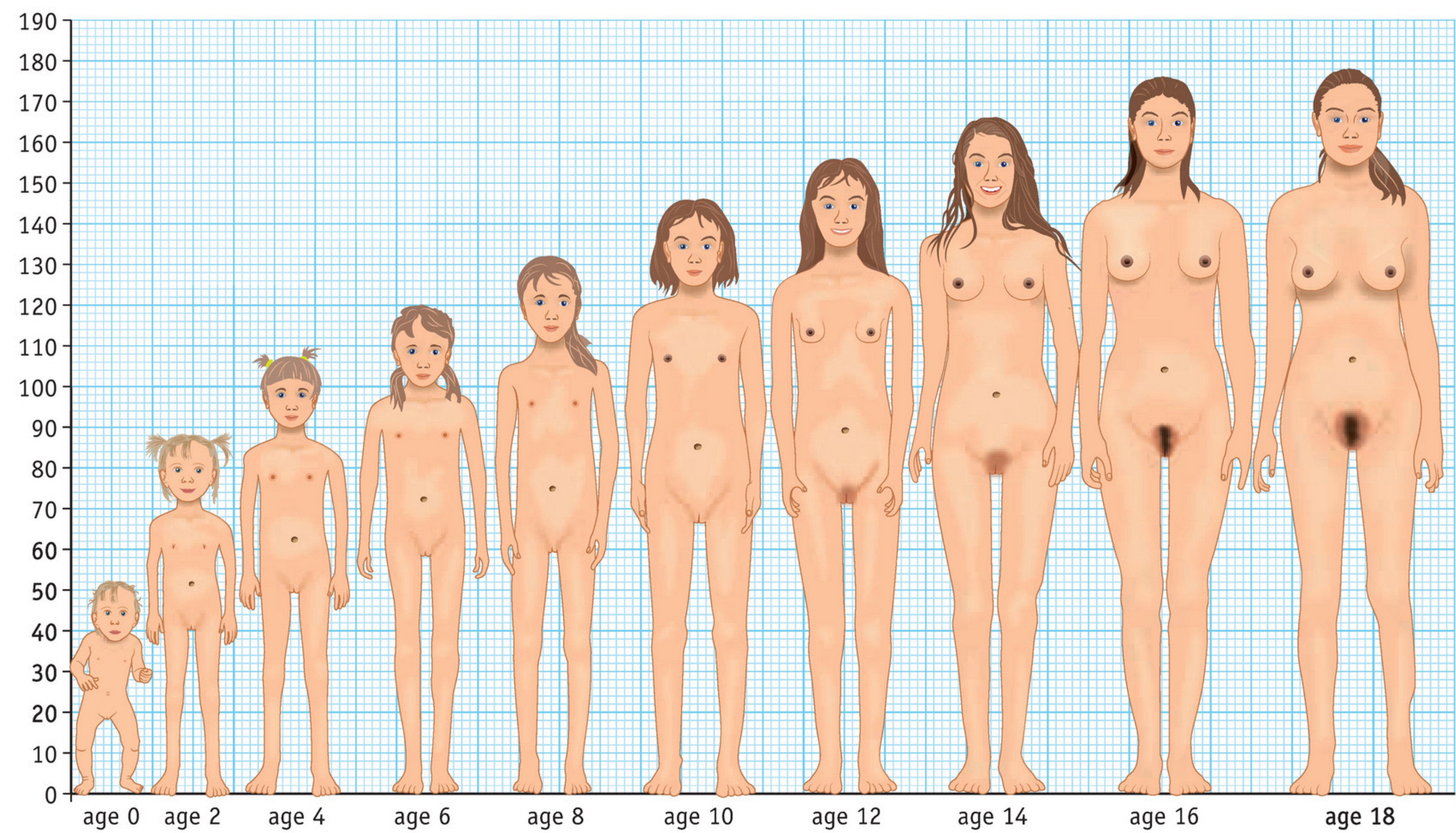
DEVELOPMENT

Developments also take place inside your body. Changes in the structure of your body are called **physical development**. Figure 1 shows how the body of a girl grows and develops into that of an adult woman.

In humans, **mental development** takes place as well as physical development. This is the development of intelligence, emotion and personality.

A third kind of development in humans is **motor development**. This means that you learn certain movements: a toddler learning how to walk, for instance.

fig. 1 Growth and physical development in a girl.



STAGES OF LIFE

You can divide the life of a human into **stages of life**. There is physical, mental and motor development in each phase. A human life consists of eight phases:

- baby
- toddler
- pre-schooler (nursery school)
- schoolchild
- teenager (or adolescent)
- young adult
- adult
- elderly

A human is born as a **baby**. For most children, this stage lasts about one year. A baby is dependent on other people. Particularly during the first year of life (age 0 to 1), a baby grows very fast. Such a period of rapid growth is called a **growth spurt**.

Children aged about 1 to 3 are called **toddlers**. Babies and toddlers learn a great deal, such as talking and moving. For example, they learn how to walk or build a tower. These are examples of motor development.

Children in the **pre-school** stage are from ages 3 to about 5. Young children learn things like how to play games, use a screen, how to ride a bicycle, draw, and play with other children (see figure 2).

A human aged 6 to 12 is called a **schoolchild** (junior school). At school, a child learns to read and write, for example, and to do arithmetic.

fig. 2 Young children play a game together.



Humans aged 12 to 16-plus are called adolescents or **teenagers**. Many teenagers have a growth spurt lasting around two years between ages 12 and 16. On average, this second growth spurt starts earlier in girls than in boys. A lot of physical and mental development takes place during **puberty**. The body's reproductive organs start to function. Girls start to develop breasts, boys get beard growth. Your emotions change and your moods can swing a great deal. You start thinking about yourself, the world and the contacts that you have with others. Maybe you fall in love for the first time.

A person aged about 16 to 21 is a **young adult**. During this stage of life, people learn to be independent.

An **adult** is fully independent. This phase lasts until about age 65. After that, someone is referred to as **elderly** or a **senior citizen**. The elderly often suffer from physical problems. Many need help as they get older.

The various stages of life do not last equally long in all people. Some children develop quickly and others more slowly. The ages stated for each stage are therefore only average ages.

KNOWLEDGE

1

- Three types of development take place in humans.
- a What is physical development?
 - b What is mental development?
 - c What is motor development?

2

- Put the eight stages of life of a human in the correct sequence.
- 1
 - 2
 - 3
 - 4
 - 5
 - 6
 - 7
 - 8

3

- a Which three sentences are correct?
- ☐ A The baby phase is from ages 0 to 2.
 - ☐ B The pre-schooler phase is from ages 1 to 4.
 - ☐ C The toddler phase is from ages 1 to 3.
 - ☐ D The teenager phase is from ages 12 to 20.
 - ☐ E The young adult phase is from ages 21 to 23.
 - ☐ F The adult phase is from ages 21 to 65.
 - ☐ G The elderly phase starts at age 65.
- b Do all stages of life last equally long in humans? Explain your answer.

4

- Humans have growth spurts in some stages of life.
- a What is a growth spurt?
 - b Which stage of life does the first growth spurt take place in?
 - c Which stage of life does the second growth spurt take place in?

5

- Eight examples of development are listed below.
- a Write down the correct stage of life next to each development. Use each stage once.
- 1 moves into student digs
 - 2 develops breasts
 - 3 learns to use a screen
 - 4 learns to use their hands
 - 5 learns to read
 - 6 learns to talk
 - 7 learns to walk with a wheeled walker
 - 8 becomes pregnant

- b** Which two developments are physical?
1 / 2 / 3 / 4 / 5 / 6 / 7 / 8
- c** Which two developments are mental?
1 / 2 / 3 / 4 / 5 / 6 / 7 / 8

6



Summary

Make a summary of this Basics section. Do that by answering the questions.

- What is physical development?
- What is mental development?
- What is motor development?
- What is a growth spurt?
- What are the stages of life for humans?
- What age range does each stage of life cover?
- What characteristics belong to the stages of life?

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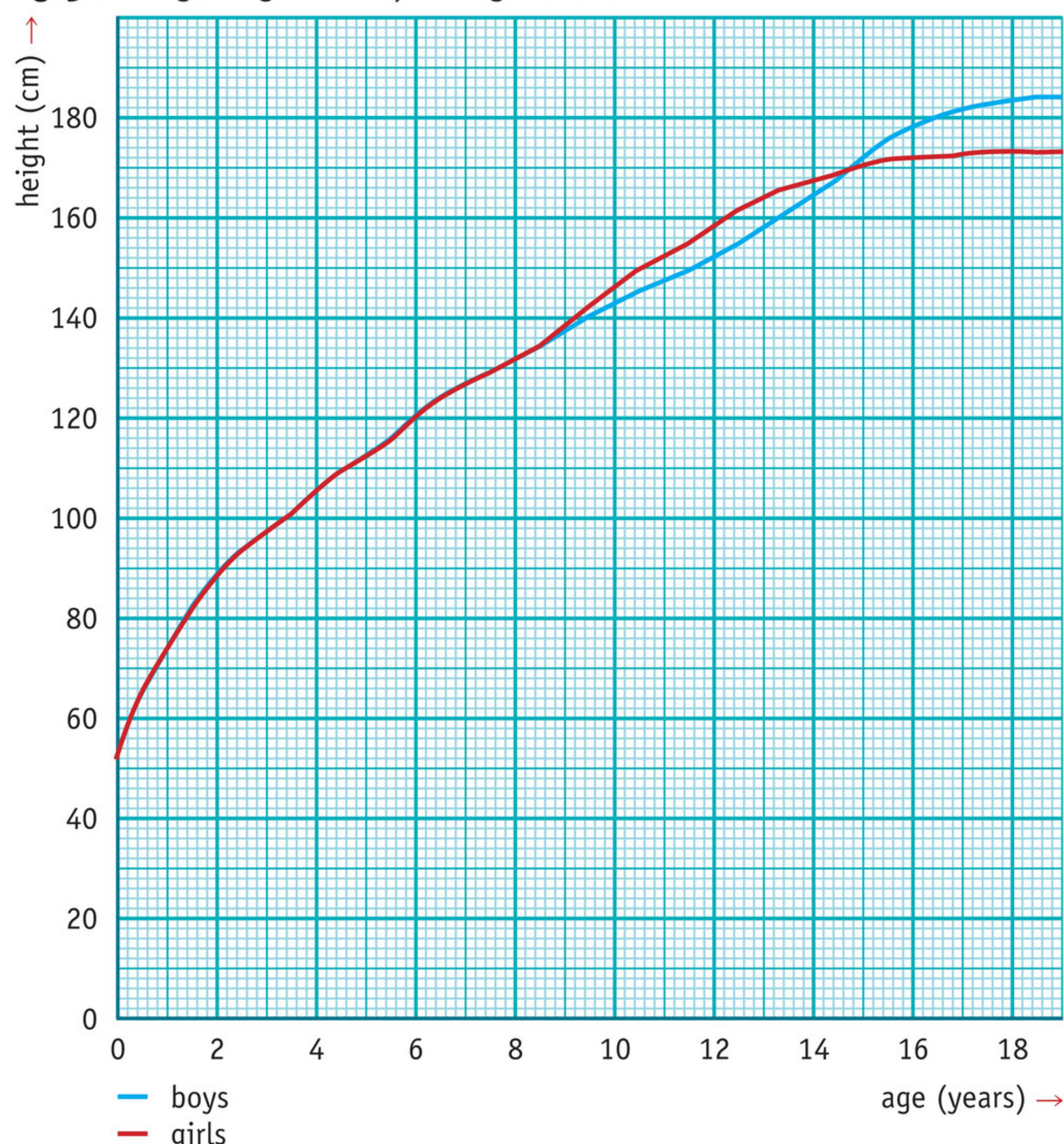
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INSIGHT

7

- Figure 3 shows a graph of the average heights of boys and girls in the Netherlands. You can see that boys eventually grow taller than girls on average.
- a** Between the ages of about 8½ and 14, girls are taller than boys on average.
Give an explanation for this.
 - b** A girl is 145 cm tall.
Based on that information, can you tell whether this girl is a schoolchild, teenager or young adult? Explain your answer.

fig. 3 Average heights of boys and girls in the Netherlands.

8

Read the text about “Harry”.

- a** Is Harry a teenager or a schoolchild? Explain your answer.
- b** You cannot say that all young people with mental disabilities also have motor and/or physical disabilities.
Explain why not.
- c** Teenagers who are frequently arrested for theft or more serious offences can be sentenced to juvenile detention. They then have to temporarily go to a juvenile detention centre (a kind of prison). If the young person was not yet 16 when they committed the offences, they can be held there for a period of up to one year.
Do you think that temporary detention in a juvenile detention centre is a good punishment for young people like Harry?

fig. 4**Harry**

Harry is a boy aged 15 whose development is delayed. His mental development is comparable to that of a 7-year-old child. He was arrested by the police a year ago because criminals were using him to commit thefts. Harry feels sorry for letting himself be used that way, but he did it because he wanted to be part of a group somewhere.

+ 9

Some parts of the body change shape as they grow. Figure 5 shows you how the head changes shape.

Which part grows faster – the part above the eyes or the part below the eyes? Give an explanation for this.

fig. 5 The growth of the head.



HOW IT FITS TOGETHER the living world

INTERNET AND YOUNG PEOPLE'S DEVELOPMENT

An American study has shown that surfing the Internet and hanging around on social media has a major influence on the development of young people. Teenagers learn to network (finding people you can work with or become friends with), they take part in discussions and learn how to make video clips and put them on the Internet. They also read articles, share knowledge and sometimes improve their knowledge of languages and their linguistic skills.

Despite this, it is important that teenagers stick to the rules for safe Internet use, because there is another side to it as well: aspects such as exposure to violence, online bullying, sexual abuse and misuse of personal data such as webcam images. Young people now have access to strangers, images and all kinds of ideas that could be harmful to themselves or others. They may for instance accept ideas or opinions uncritically as the truth. Another disadvantage is that they are not exercising during all those lengthy periods on the net, which is bad for their motor development. The risk of developing diabetes and cardiovascular disease can also increase.

fig. 6 Staying safe on the Internet.



10

Read the text “Internet and young people’s development”.

- a** Using the Internet can have a *positive* effect on your mental development.
Explain this using three examples.
- b** Using the Internet can also have a *negative* effect on your mental development.
Explain this using three examples.
- c** Explain how using the Internet can have a negative effect on your motor development.
- d** Computers, tablets and mobile phones can be used in every stage of life to support the mental or physical development.
Pick a stage of life and think of a positive way of using a computer, tablet or mobile phone in that stage of life.

 Go to the *Flash cards* and the *Test yourself* section.

5 Making food

LEARNING OBJECTIVES

- 1.5.11 You can explain that photosynthesis makes food for animals and people. ► Practical activities 8 and 9
- 1.5.12 You can describe photosynthesis.
- 1.5.13 You can state which parts of plants are used as food by humans.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	1.5.11	1.5.12	1.5.13
Remembering	1	2abc	3a
Understanding	4	2d, 4	3b, 4
Using	10a	5, 9abc	7, 10a
Analysing	8, 10b	6, 9d	

Plants are indispensable for life on our planet. They make food for all other organisms on Earth. They do not eat other organisms themselves.

SUBSTANCES AND ENERGY

Humans and animals need oxygen, nutrients and energy to stay alive. You get oxygen from the air you breathe in. Your food gives you **nutrients**: substances that are needed for your body to grow and develop. You also get your energy from the food that you eat or drink. Almost all your food comes from plants or animals.

Humans and animals eat other organisms or parts of other organisms. Plants do not feed on other organisms. They make the substances themselves that they are made of.

GLUCOSE

An important substance for plants is **glucose**. Glucose contains a lot of energy. It is a kind of sugar. A plant uses glucose to make all sorts of other high-energy substances, including the substances that the plant itself is made of. The plant can grow and make new parts, such as leaves, stems, fruits and seeds.

The plant makes the glucose it needs all by itself. It needs three things for that: water, carbon dioxide and energy (light). The plant gets water from the ground through its roots. The plant absorbs carbon dioxide from the air through small openings in its leaves. Carbon dioxide is a gas, just like oxygen. A plant also needs energy to make glucose. It gets that energy from light, for example from the sun.

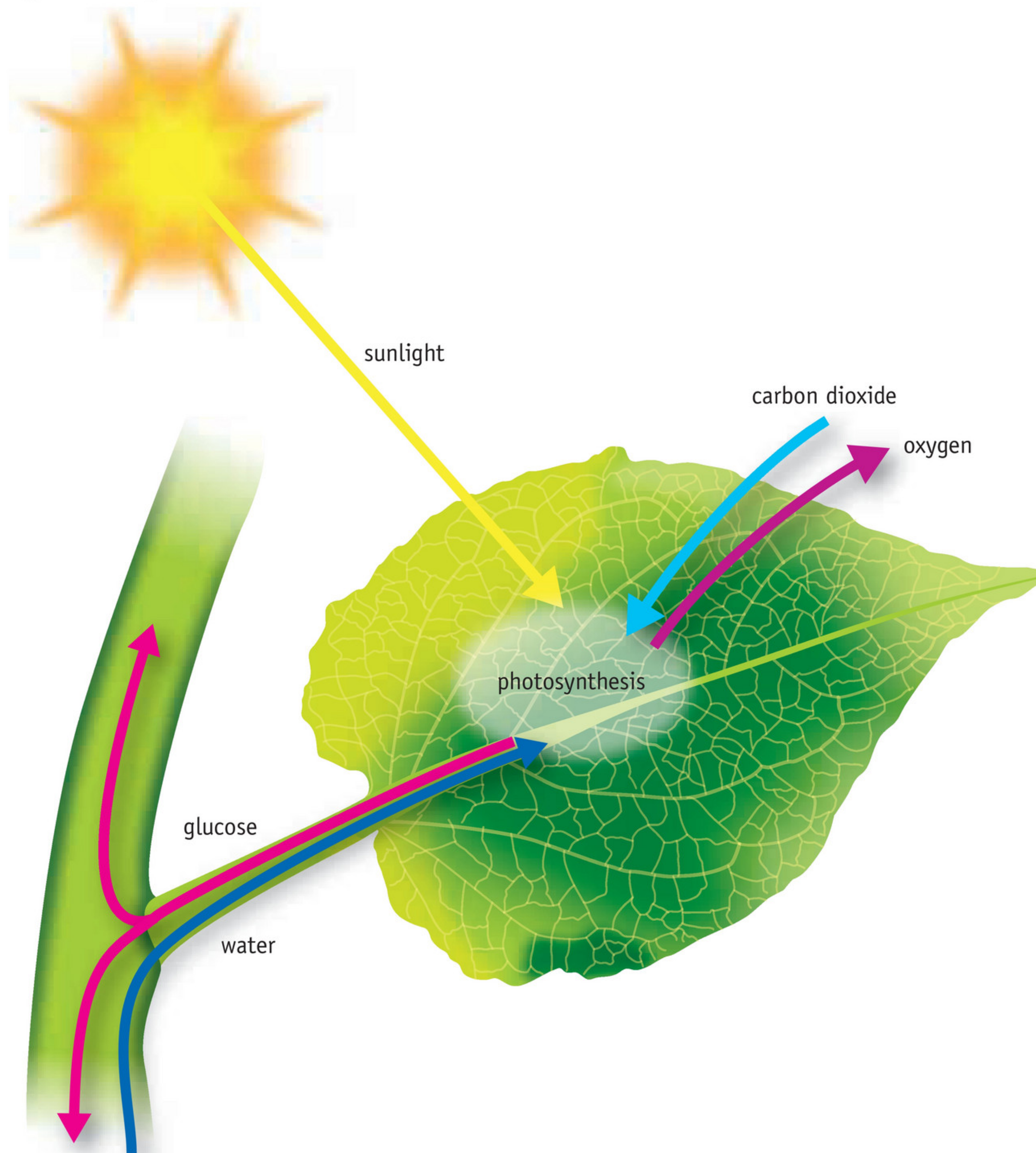
PHOTOSYNTHESIS

The process where a plant makes glucose using energy from light is called **photosynthesis**. Photosynthesis takes place in all the green parts of a plant, but especially in the leaves. Photosynthesis not only produces glucose: it also releases oxygen. The plant releases oxygen into the air through the same small openings in its leaves.

You can summarise photosynthesis as (see figure 1):

water + carbon dioxide + energy from light → glucose + oxygen

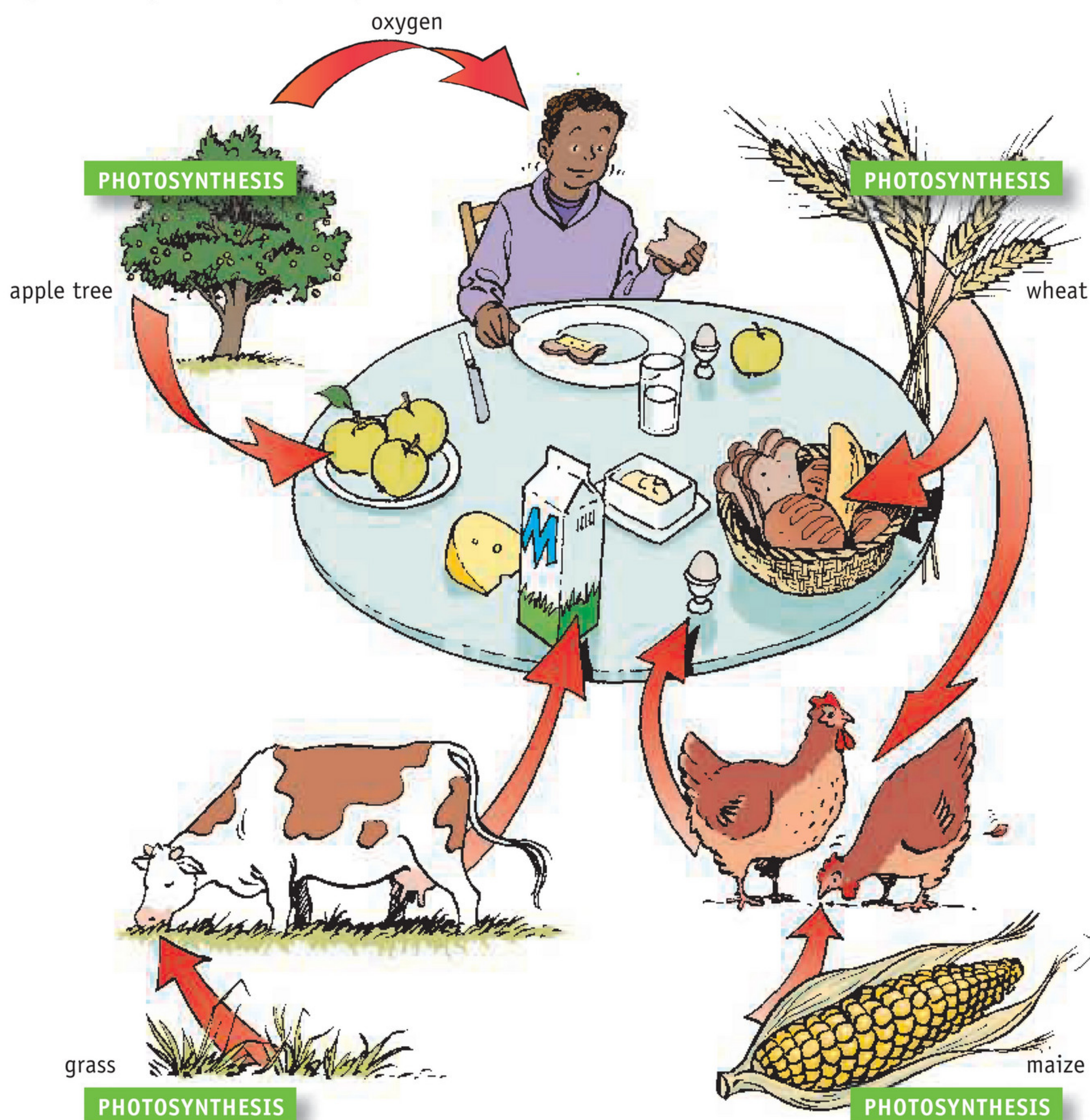
fig. 1 Photosynthesis.



WHY PHOTOSYNTHESIS IS IMPORTANT

Humans and animals eat plants. Photosynthesis is therefore also very important for humans and animals. Almost everything that people eat ultimately comes from plants. A piece of meat may come from a cow, for example, but that cow ate grass. An egg comes from a chicken, but that chicken ate maize (see figure 2).

Photosynthesis is how new food can keep being produced on Earth. It also keeps renewing the oxygen. Humans and animals take in oxygen from the air when they breathe. Because photosynthesis is generating oxygen, there is always enough oxygen in the air. Without photosynthesis, the oxygen in the air would slowly all get used up.

fig. 2 The importance of photosynthesis.**EDIBLE PARTS**

People use parts of plants as food. We eat the fruits of an apple tree (the apples). We also eat the fruits of a tomato plant (the tomatoes). There are other plants such as rice and grains that we use the seeds of. Sometimes people eat plant roots too, for example carrots, parsnips, radishes and beetroot. There are other plants such as asparagus and celery that we use the stems of. Most vegetables are the leaves of plants, such as lettuce, spinach, cabbage and leek. People sometimes also eat the flowers of plants.

KNOWLEDGE**1**

Give two reasons why photosynthesis is important for people.

2

Plants absorb substances from their surroundings in photosynthesis. They also release substances.

a Which two substances does a plant absorb for photosynthesis?

glucose / carbon dioxide / water / oxygen

- b What else does a plant need for photosynthesis?
- c Which two substances are produced in photosynthesis?
glucose / carbon dioxide / water / oxygen
- d Explain that carbon dioxide is needed for a plant to grow.

3

People use plants as food.

- a Which six parts of plants are eaten by people?
- b Give five examples of vegetable foods (plants or parts of plants).

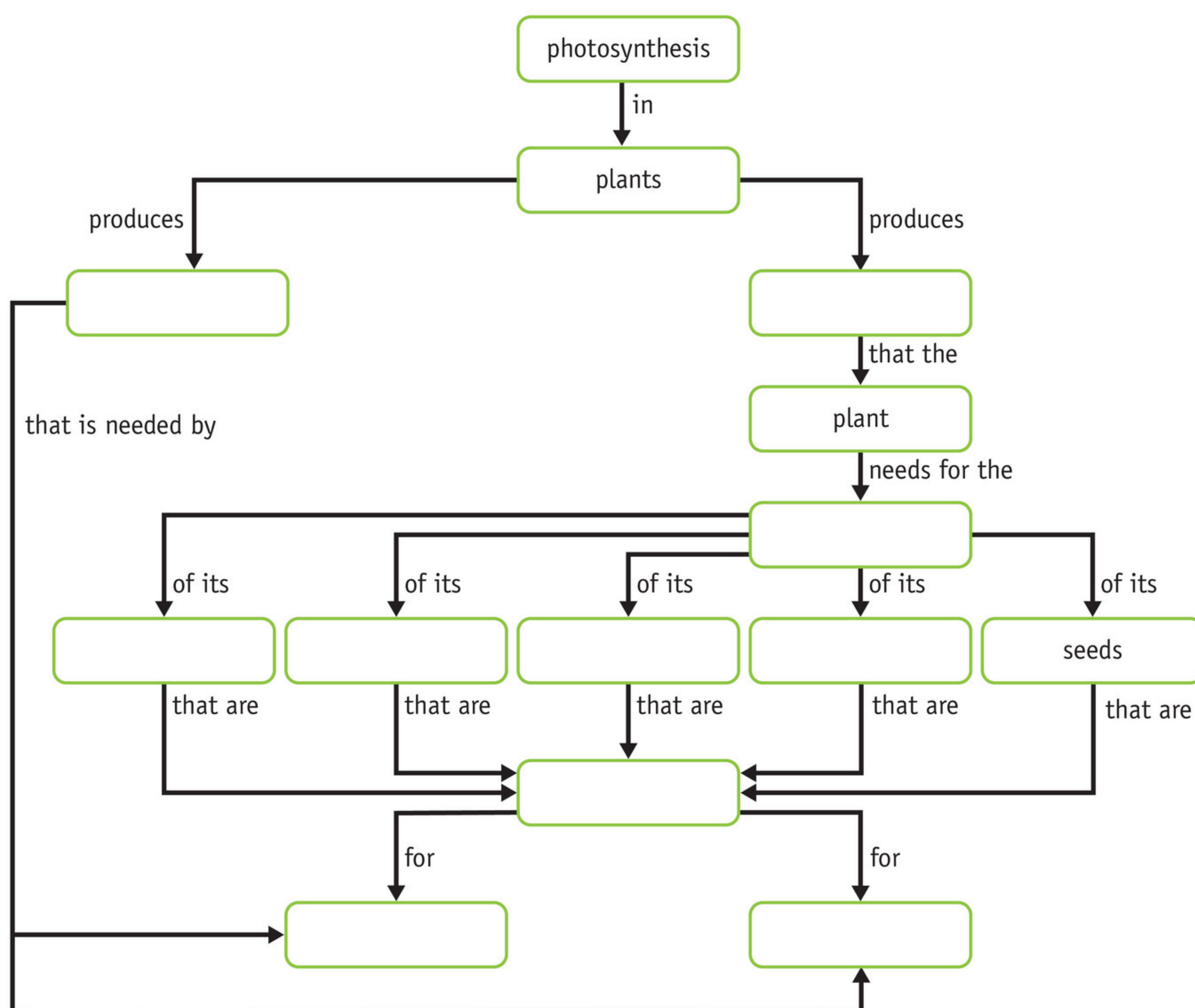
4

Summary

Make a word web about photosynthesis. Include the most important concepts from this Basics section. Connect the words that belong together. If you wish, you can use figure 3 for your word web. Use the following words: *animal – food – fruit – glucose – growth – human – leaf – oxygen – root – stem*.



fig. 3



INSIGHT

5

Plants need light for photosynthesis.

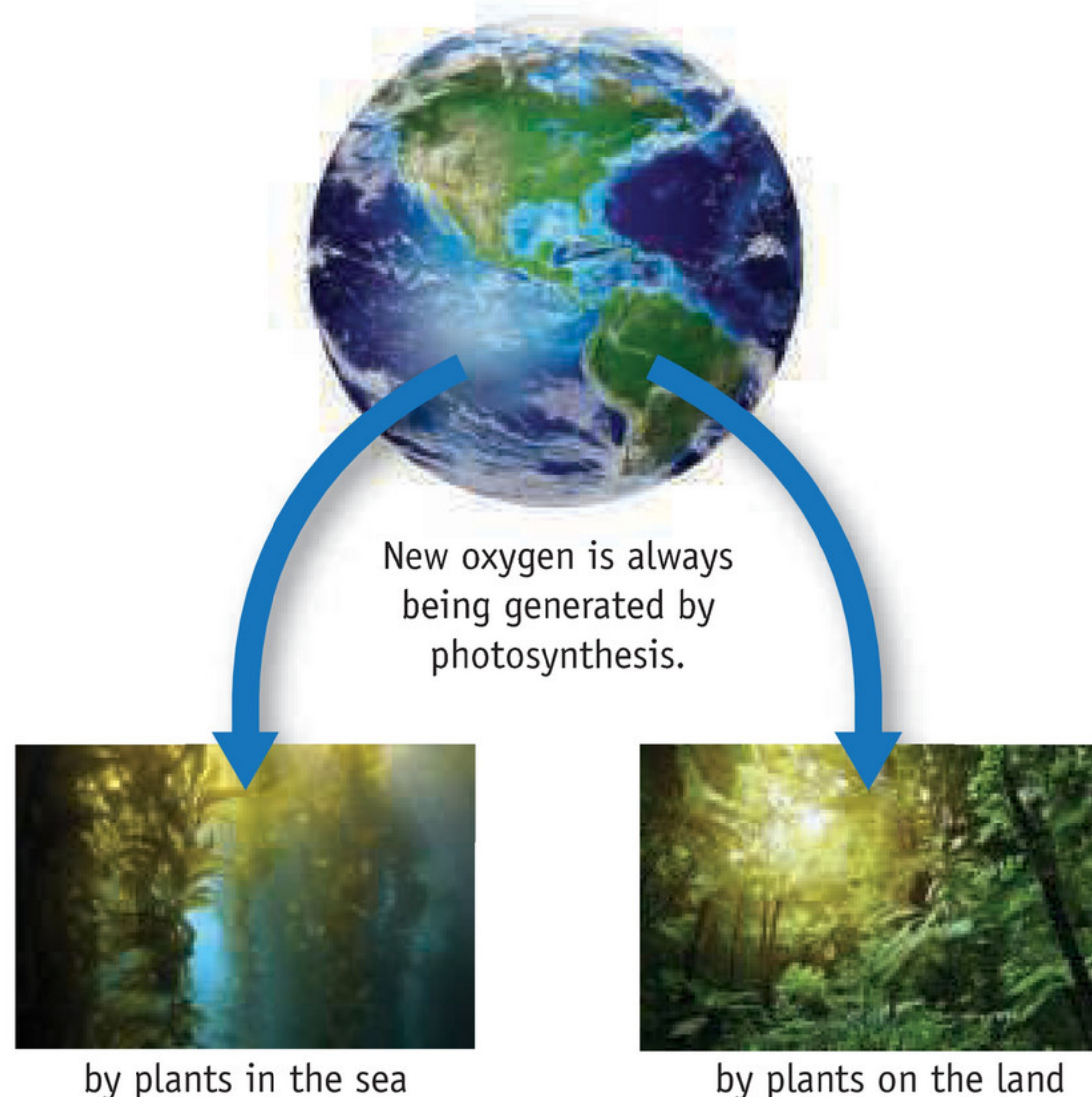
- a Does photosynthesis take place in plants on cloudy days? Explain your answer.
- b Does photosynthesis take place in houseplants at night in a room with the lights on? Explain your answer.

6

Water plants are plants that grow in or on the water. They can absorb carbon dioxide from the water. Water plants are responsible for a large proportion of the oxygen production on the Earth.

Study figure 4 and give an explanation for this.

fig. 4 Photosynthesis produces oxygen.



7

Figure 5 shows five photos of vegetables.

Write down the part of the plant next to each vegetable. Choose between: *leaf* – *stem* – *fruit* – *root* – *seed*.

- 1 A bell pepper is a
- 2 A pea is a
- 3 Spinach is a
- 4 A beet is a
- 5 Celery is a

fig. 5 Edible parts of plants.



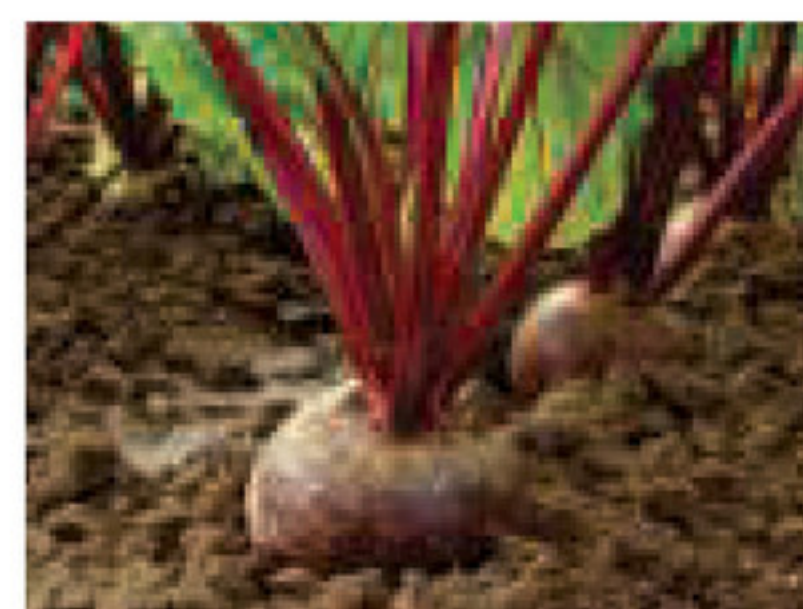
1 bell pepper



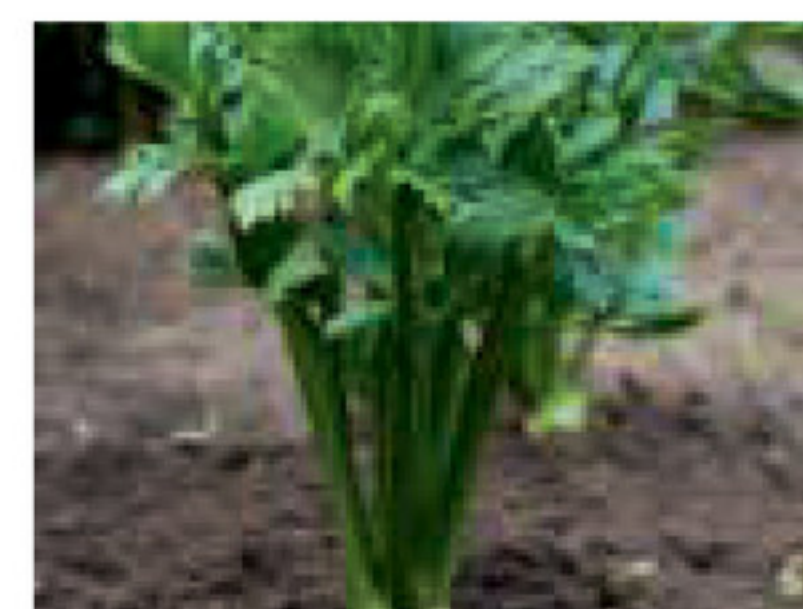
2 pea



3 spinach



4 beetroot



5 celery

+ 8

You could say that a human runs on solar energy. Explain why.

HOW IT FITS TOGETHER biology in professional life

TOMATO GROWER

Jessica grows tomatoes in the Westland region. That is an area in the west of the Netherlands that has a lot of greenhouse horticulture.

“Tomato plants don’t grow in the winter because it’s too cold. Growing plants in a greenhouse lets you keep them warm in the winter, but just keeping the plants warm isn’t enough. There’s much less light in the winter than in the summer as well. The more light a plant gets, the more photosynthesis takes place and the better it will grow. We have what is known as a CHP

system – combined heat and power – for our tomato greenhouse. The gas generators supply heat, electricity and carbon dioxide. We use the heat and the carbon dioxide in the greenhouses to help the plants grow. We use the electricity that is produced for the lighting and any energy we have left over is delivered to an electricity company. So market gardeners are often also energy suppliers.”

fig. 6 Jessica in one of her greenhouses.



9

Read the “Tomato grower” text.

- a Greenhouses are mostly made of glass.
Does photosynthesis in plants occur under glass? Explain your answer.
- b Does photosynthesis take place in the roots of a tomato plant? Explain your answer.
- c Does photosynthesis happen in the stems of a tomato plant? Explain your answer.
- d Does photosynthesis take place in a tomato? Explain your answer.

+ 10

- a Describe in four steps how energy from light gets into people through tomatoes.
1
.....
2
.....
3
.....
4
.....
- b The text states various ways in which substances and energy are used in a greenhouse. Example: heat (a form of energy) is used by plants for growth. In the text, find five ways in which substances or energy are used in the greenhouse. Do it like this: (the substance or energy) is used by for

 Go to the *Flash cards* and the *Test yourself* section.

6

All different

LEARNING OBJECTIVES

- 1.6.14 You can describe adaptations in plants.
- 1.6.15 You can describe adaptations in animals.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	1.6.14	1.6.15
Remembering		
Understanding	4, 5, 6ab	1, 2, 3, 5, 8a, 9a
Using	6c, 10a, 12ab	7, 8b, 9b
Analysing	6d, 10b, 12c	11

Animals and plants need to feed, defend themselves and reproduce. Each species does this in its own way.

ADAPTATIONS

All organisms have adaptations to their way of life and their living environment. These adaptations can be related to all sorts of functions, such as respiration, motion, nutrition, defence and reproduction. Adaptations allow organisms (or parts of organisms) to perform these functions better.

LIVING ENVIRONMENT

Animals that live in water often have adaptations that make this possible. Fish have gills to breathe and fins to let them stay upright in the water. Their skin is covered in scales, with a layer of mucus (slime) on top of that. This mucus makes the skin very slippery and so there is little resistance when they are swimming.

The body shape of fish also reduces their resistance in the water. Head, torso and tail blend gradually into each other. This body shape is said to be **streamlined**. Birds and mammals that live in the water are also streamlined (see figure 1).

fig. 1 Animals that live in the water.



1 penguin (a bird)

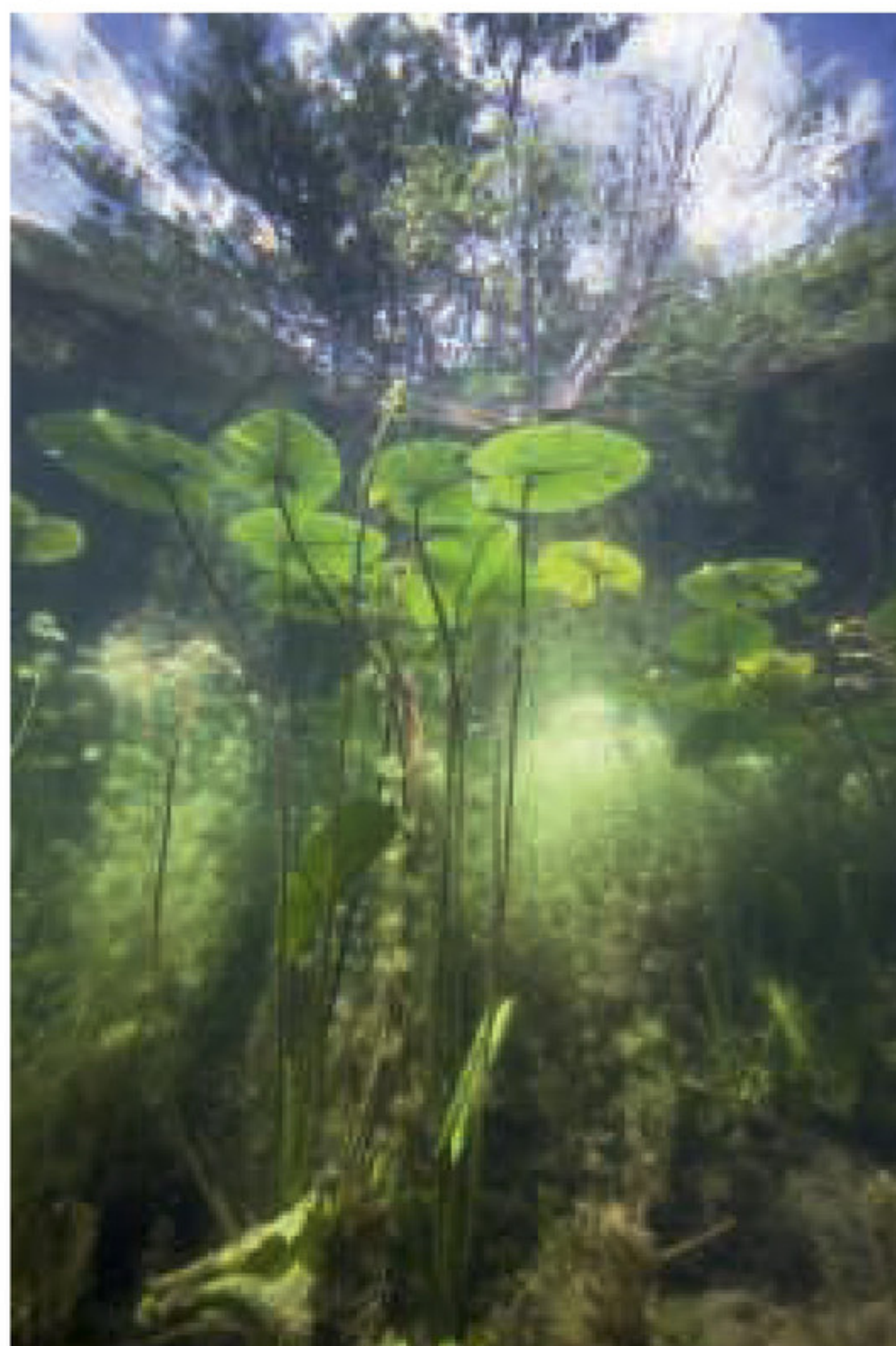


2 shark (a fish)

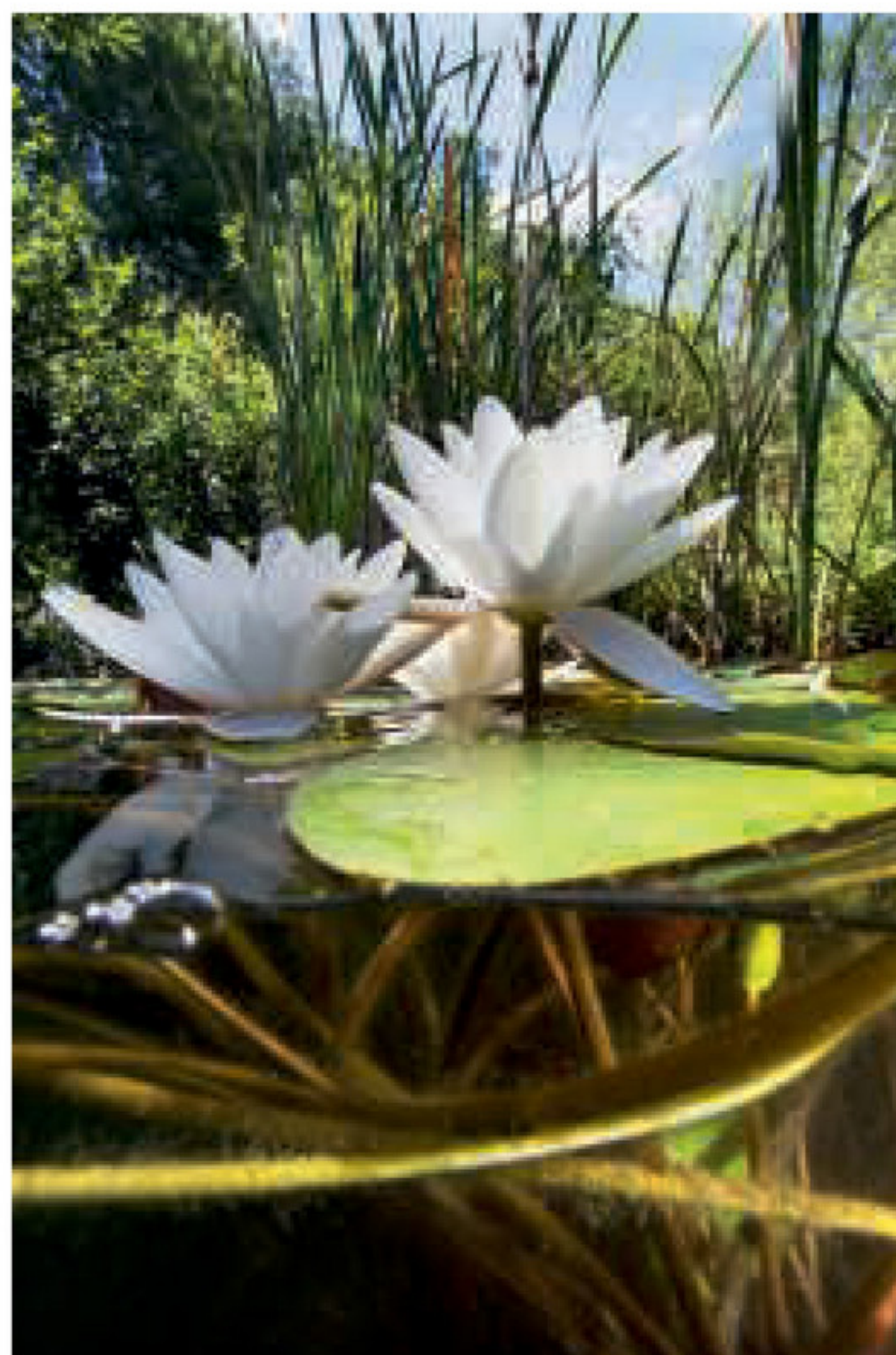


3 dolphin (a mammal)

Plants that live in water do not have many rigid parts. Their weight is supported by the water, just as it is for animals that live in the water. The stems are weak. Plants need light for photosynthesis, so most water plants grow in the upper layer of water. Water lilies are attached to the ground by their roots (see figure 2). The leaves float on the water.

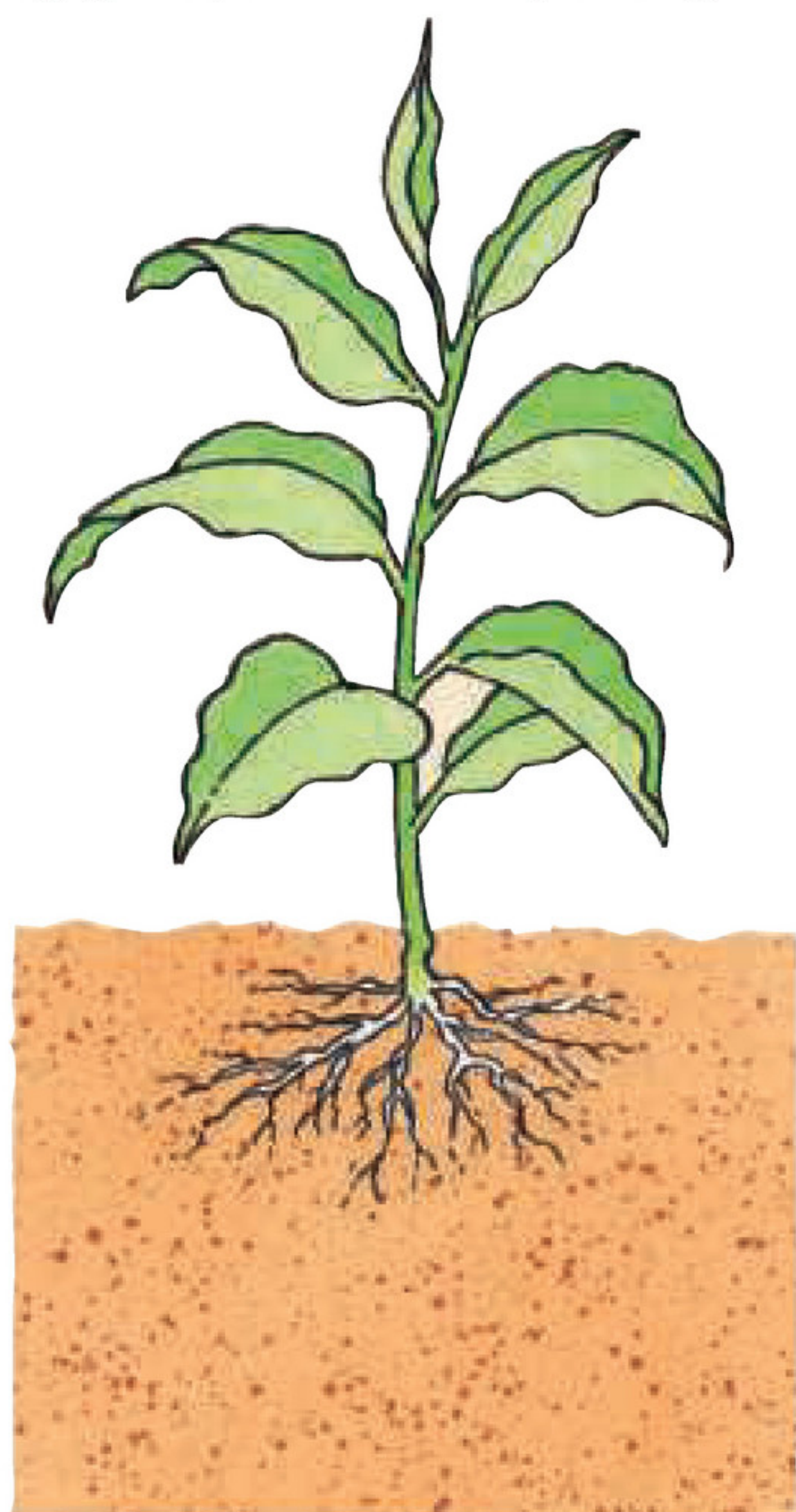
fig. 2 Plants that live in the water.

1 water lily: stems and roots in the water

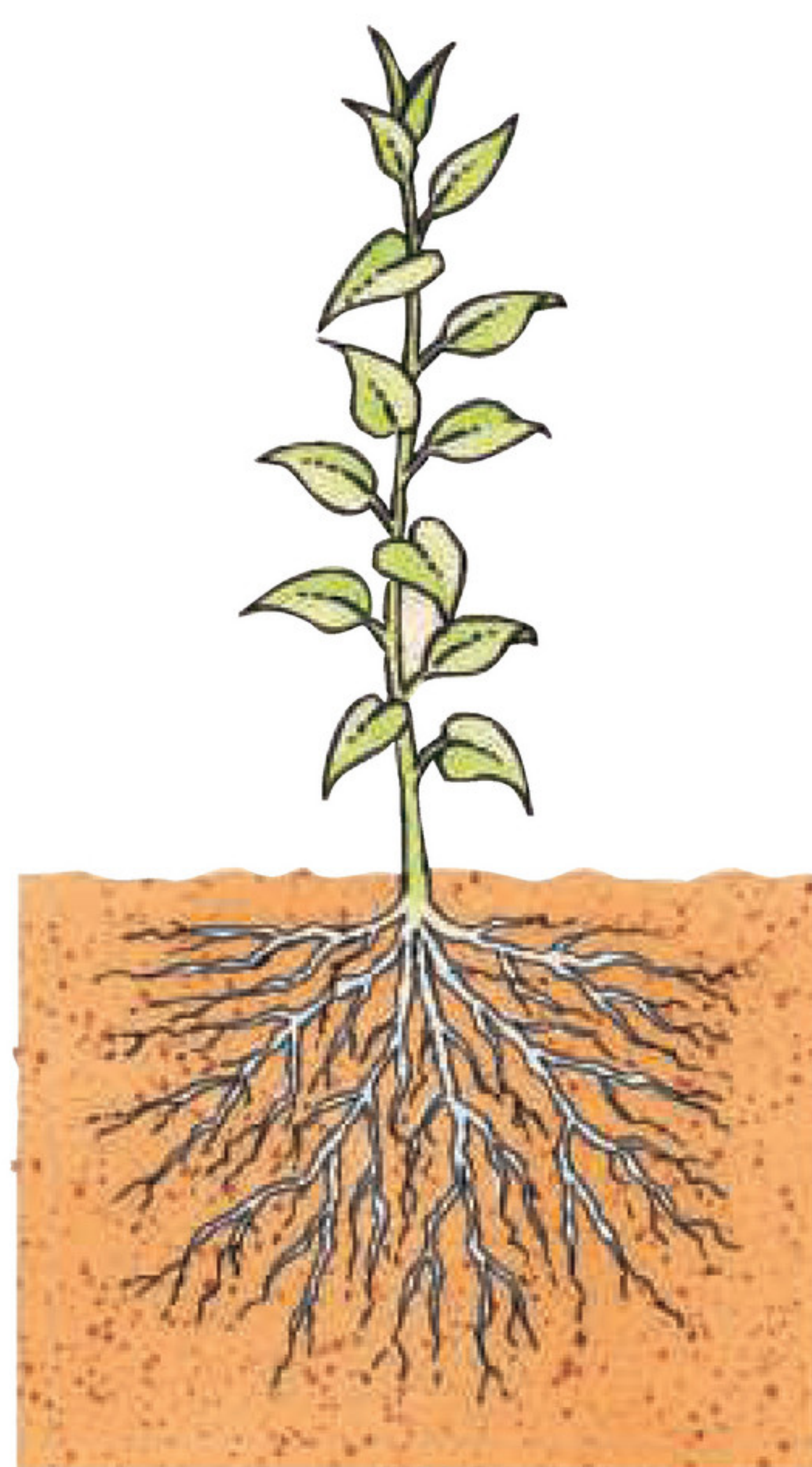


2 water lily: leaves and flowers above the water

Plants that live on land must protect themselves against **dehydration**. If the plant loses too much water, it can die. Land plants often have adaptations to avoid this (see figure 3). Small, thick leaves can retain moisture well. Water evaporates more easily from large, flat leaves. However, more photosynthesis can take place in large leaves. If the soil is always moist, a plant does not need a lot of roots.

fig. 3 Adaptations in land plants against dehydration.

1 in a moist environment: large, flat leaves, not many roots or small roots



2 in a dry environment: small, thick leaves, a lot of roots or large roots

FEEDING

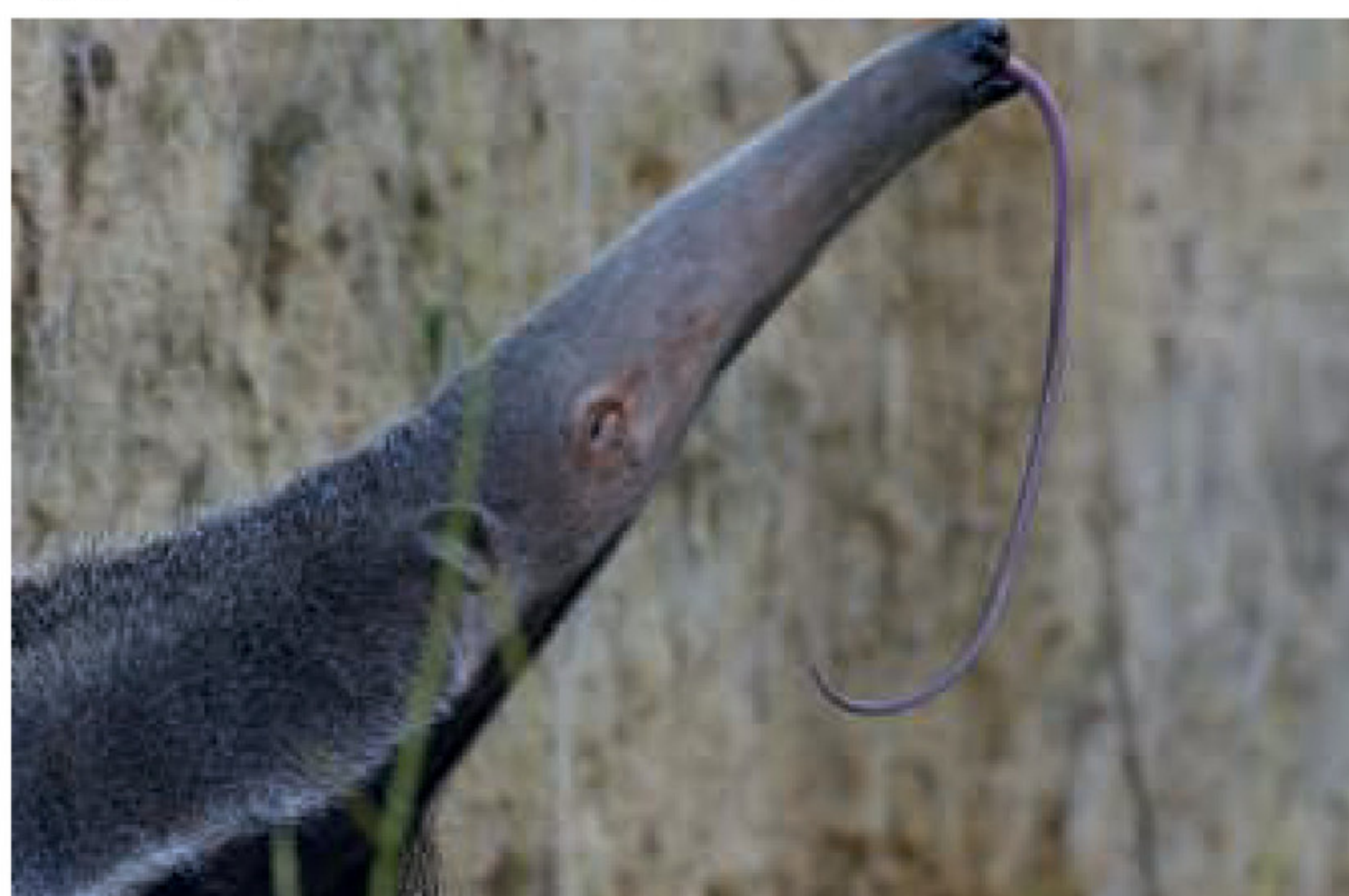
Several birds' heads with different types of beaks are drawn in figure 4. The beaks are adapted to the food that the birds eat. The **conical beak** is good for eating seeds. Because it is short, the bird can exert a lot of force with it. The **tweezer-shaped beak** is pointy. The bird can use it to catch insects easily, for example ones that hide in cracks. Birds of prey and owls have sharply **hooked beaks**. These are adapted for ripping prey animals apart. A **pointed beak** is for digging deep into wet ground for animals that live there. Waterbirds often have **flattened beaks**. They take water into their beaks and push it out through the "filter". Plankton lives in the water: very small animals and plants. They swallow the plankton that remains behind.

fig. 4 Beaks in birds.



Other animals have also adaptations to the choice of diet. An anteater, for instance, has a long thin tongue with small hooks and a lot of saliva (see figure 5). Ants stick firmly on that tongue. A squirrel has four strong, razor-sharp teeth at the front of its mouth. These let it bite into hard food such as nuts and seeds.

fig. 5 Adaptation to the choice of diet.



1 giant anteater: long, sticky tongue



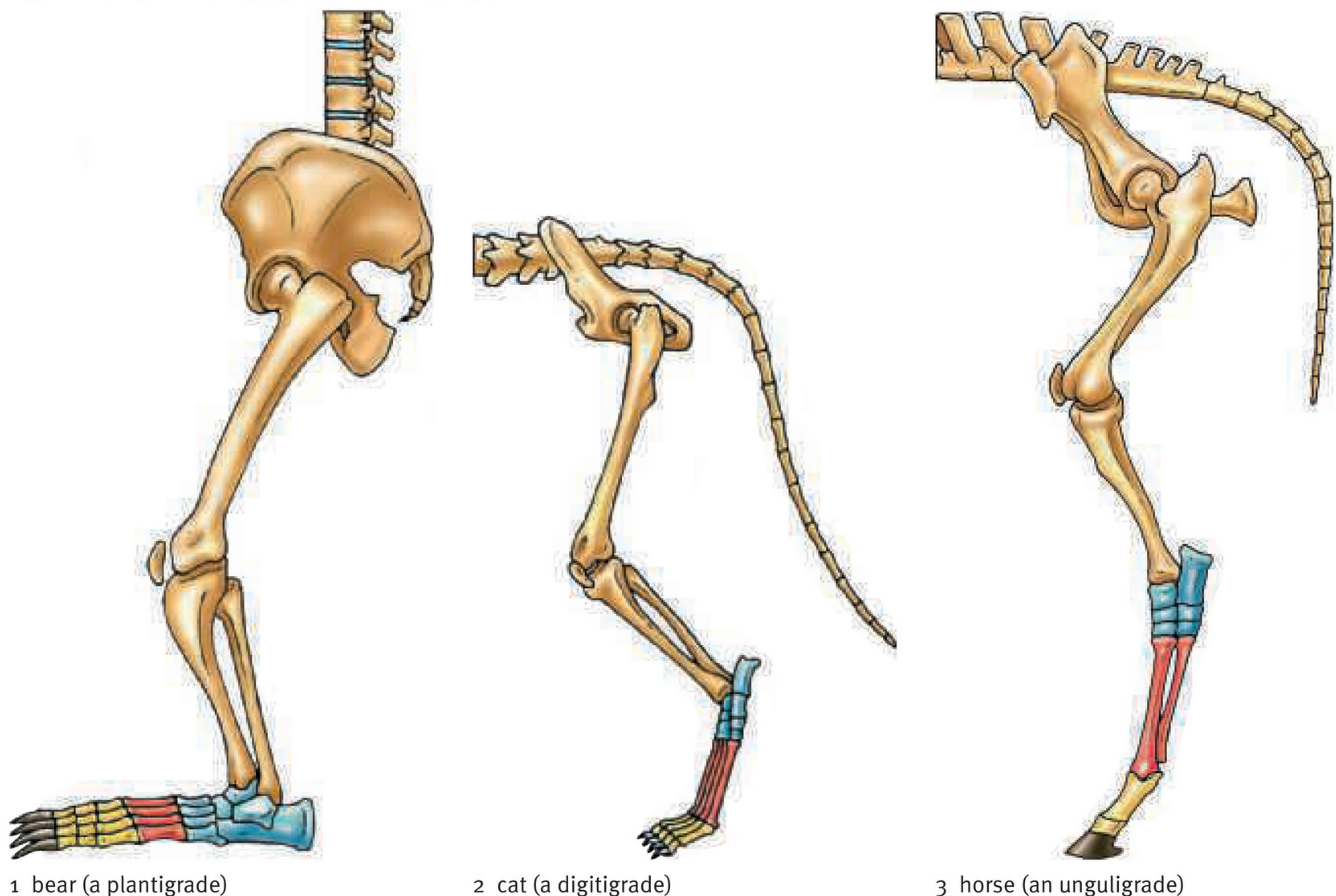
2 squirrel: large sharp teeth

MOVING

Figure 6 shows the hind legs of a bear, a cat and a horse. A bear walks on the whole sole of its foot. Animals that walk on the whole sole of the foot are called **plantigrades**. Humans are also plantigrades. Cats walk on their toes: they are **digitigrades**. Horses are **unguligrades**, they walk on the tips of their toes. The tops are covered with a hoof. They are therefore sometimes also known as hoofed animals.

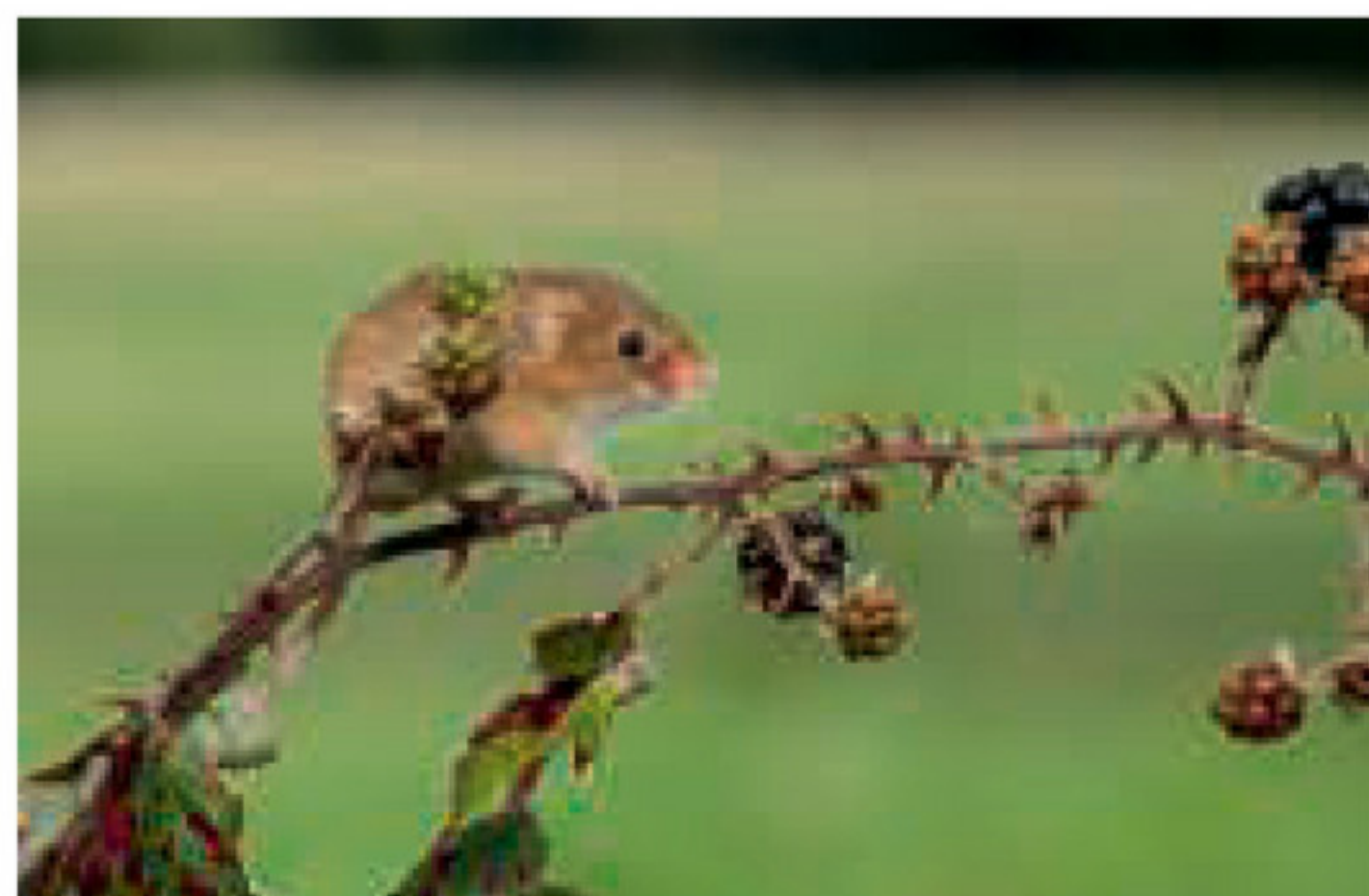
The way of walking is an adaptation to the ground that the animal lives on. Walking on a hard surface is more efficient if only a small part of the foot is in contact with the ground. On a soft surface, though, it is better to walk on the entire foot. The legs will then not sink in as much.

fig. 6 Plantigrades, digitigrades and unguligrades.



DEFENCE

Most organisms have adaptations to protect themselves from enemies. Brambles have thorns on their stems (see figure 7). They use these to defend themselves against animals (and people!) who want to eat the leaves or fruits. Nettle leaves have stinging hairs. When you touch them, your skin starts to itch and sting. Some plants produce toxins (poisons). The coffee plant, for example, produces caffeine – a substance that paralyses insects that eat the plant.

fig. 7 Defences in plants.

1 The thorns of brambles protect against damage from being eaten.



2 The leaves of stinging nettles have stinging hairs.



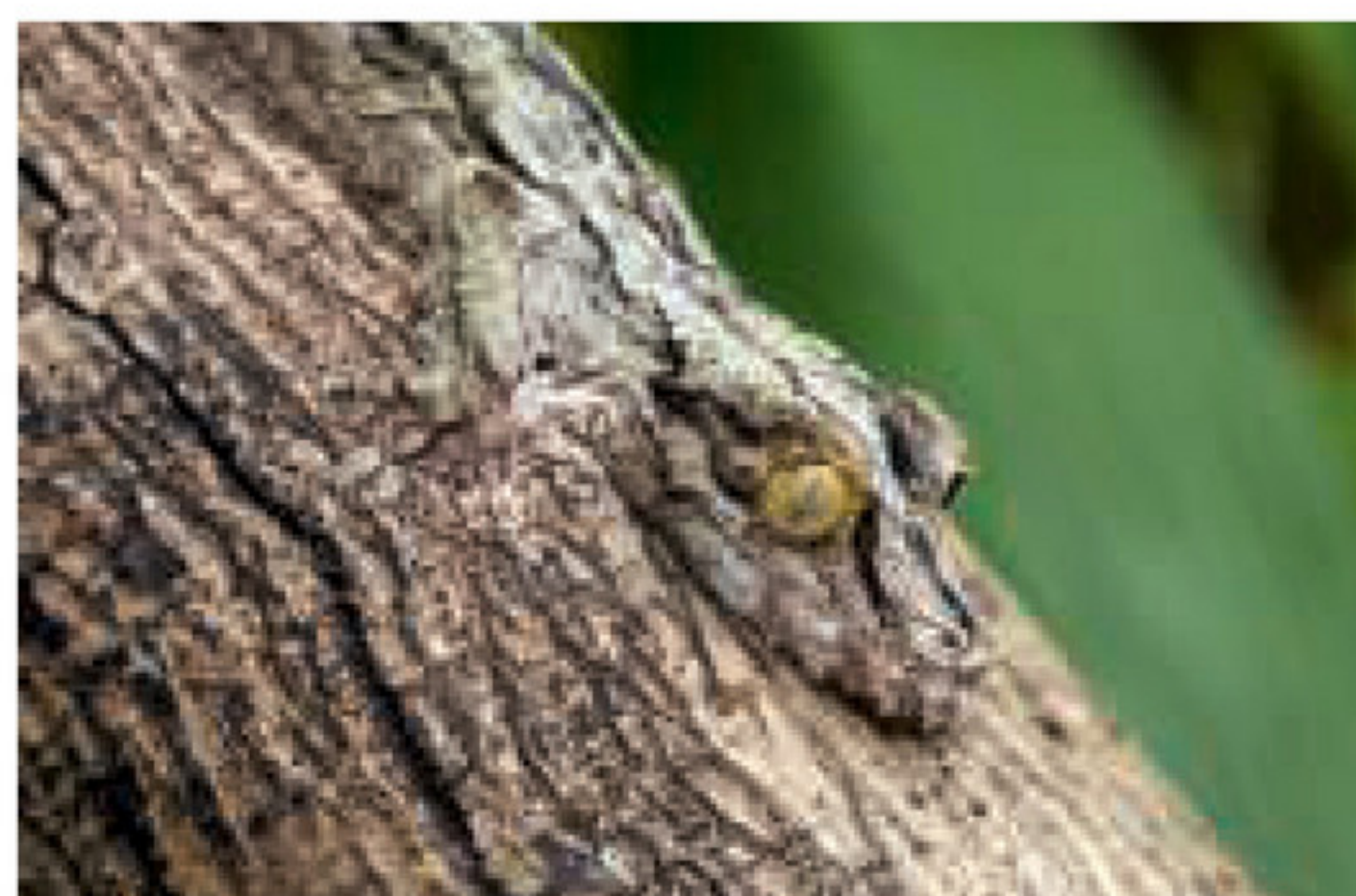
3 The berries of coffee plants contain caffeine.

Some animals also defend themselves with spines, such as the hedgehog (see figure 8). Other animals such as the leaf-tail gecko have **camouflage**. They can make themselves almost invisible to enemies. Figure 8 shows some more adaptations in animals for defence against enemies.

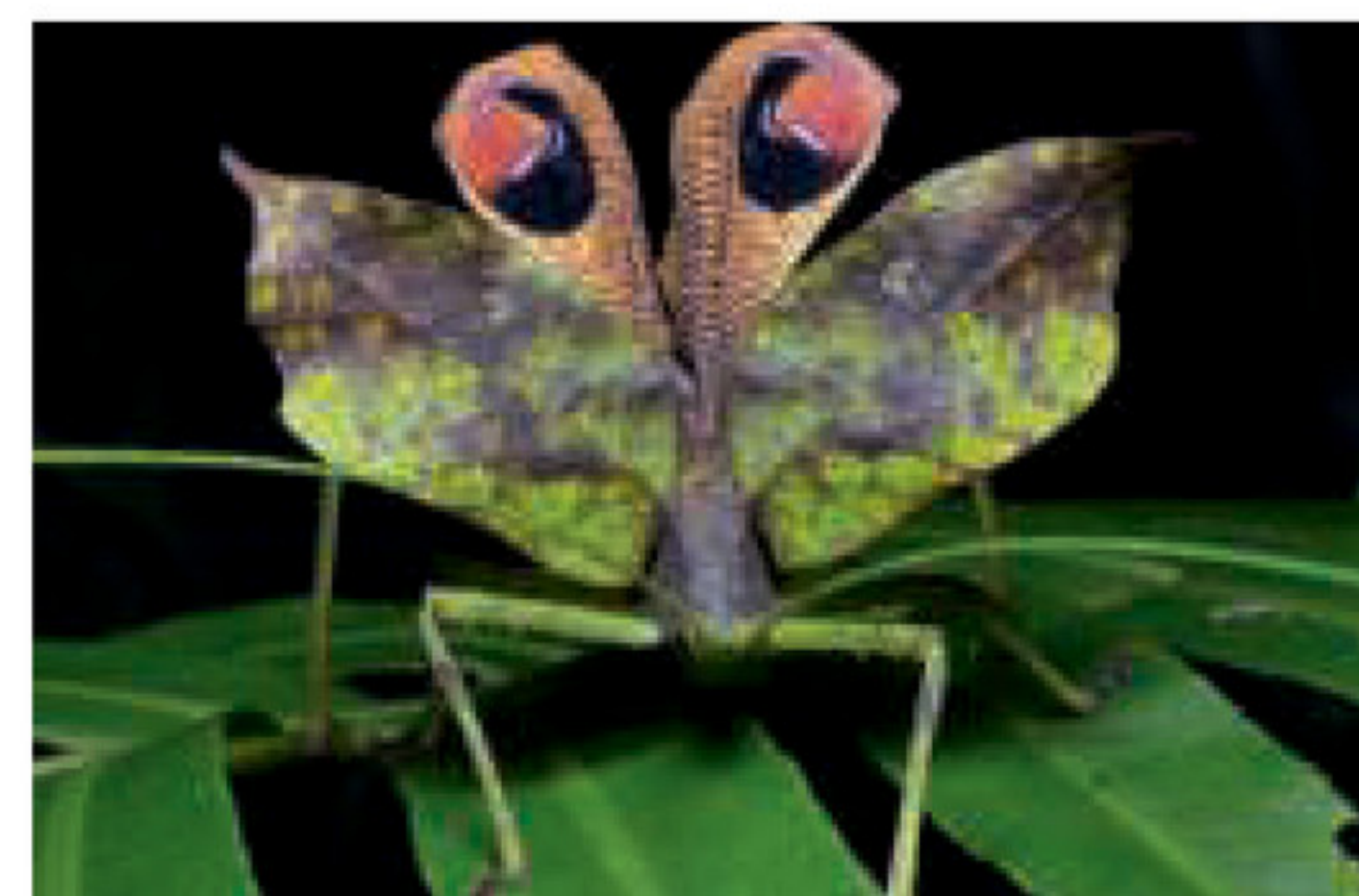
An animal can also protect itself against its living environment. A deer, for instance, has fur for protection from the cold.

fig. 8 Defences in animals.

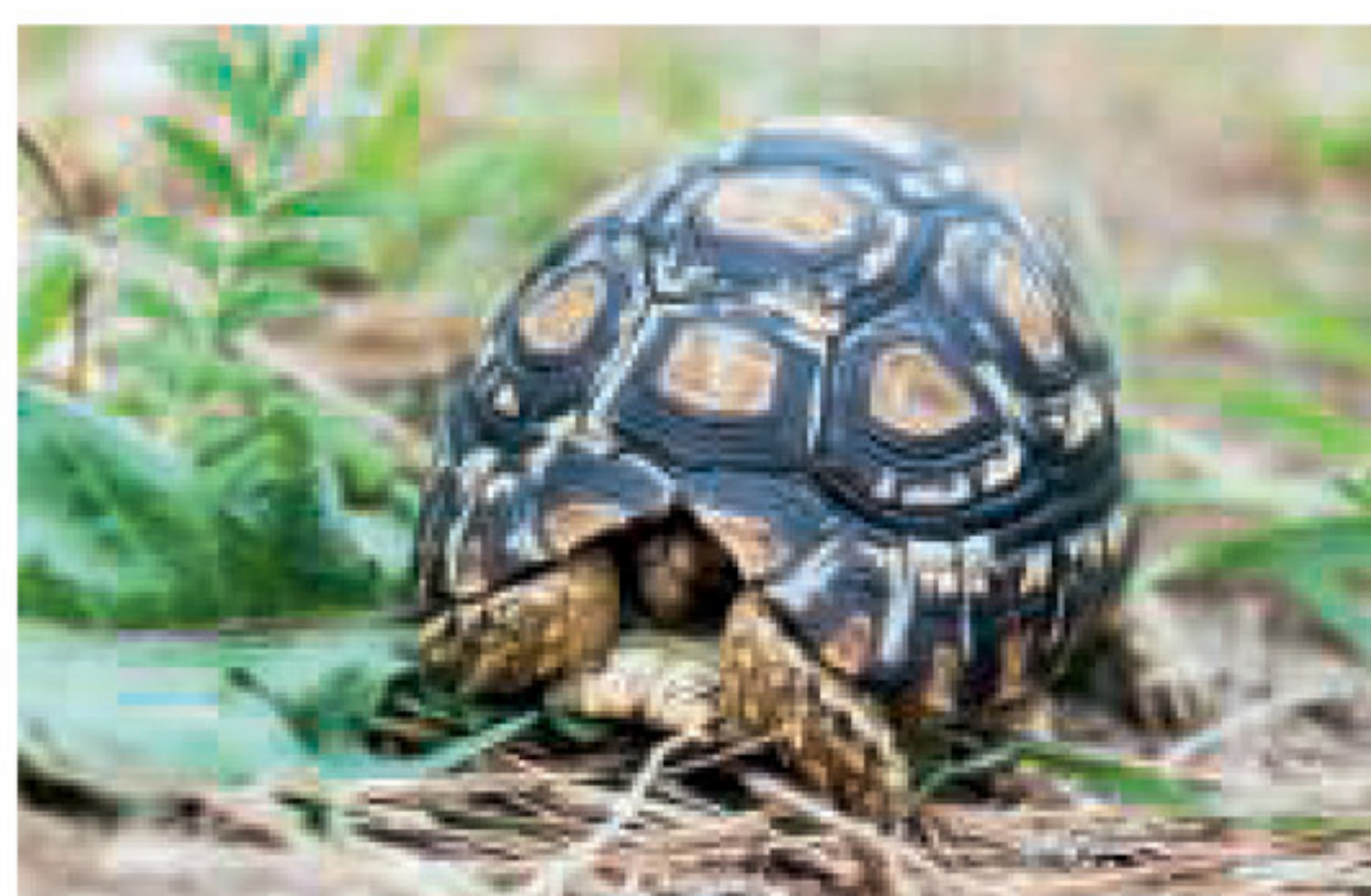
1 A hedgehog has spines.



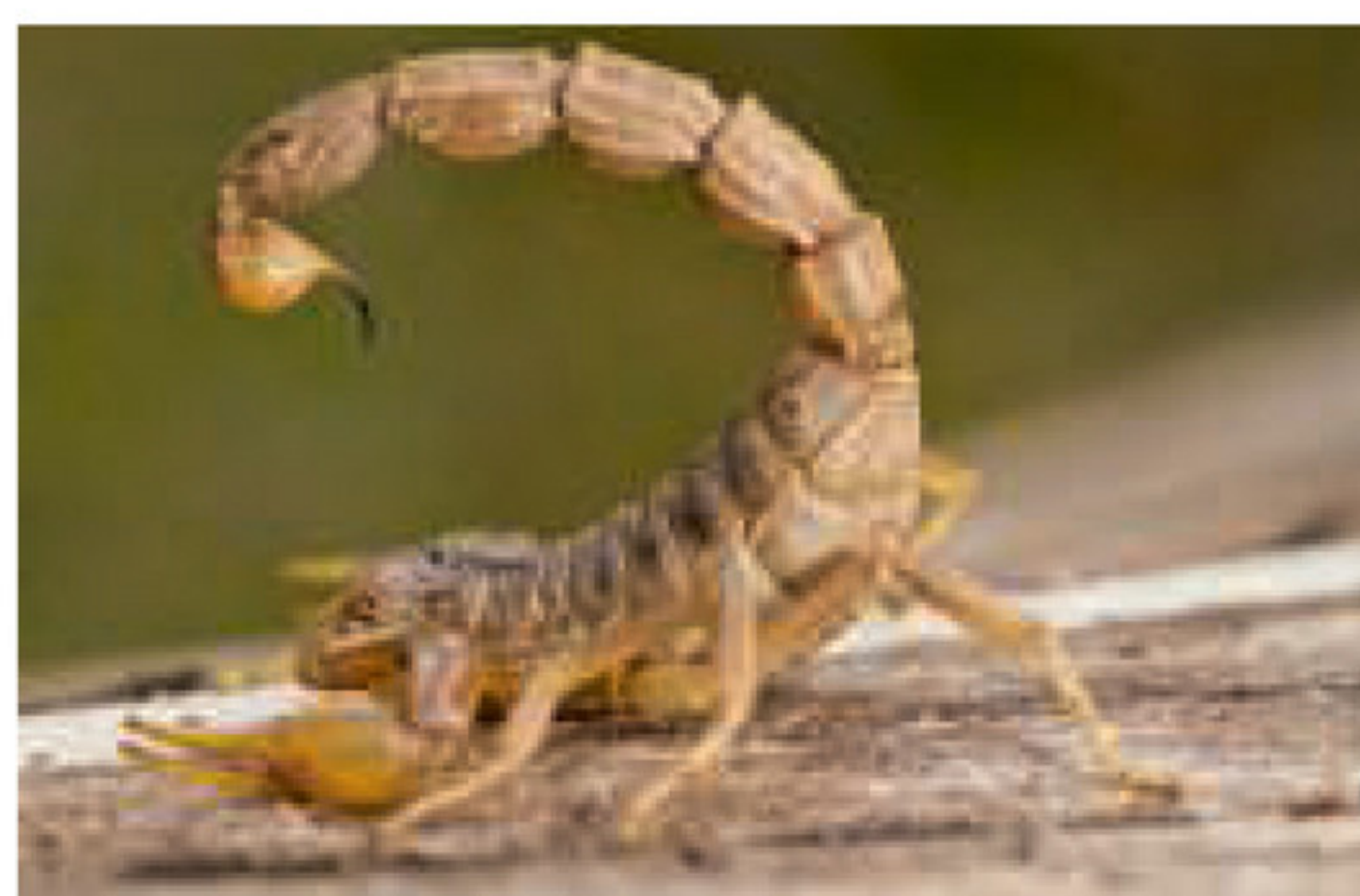
2 A leaf-tail gecko is camouflaged.



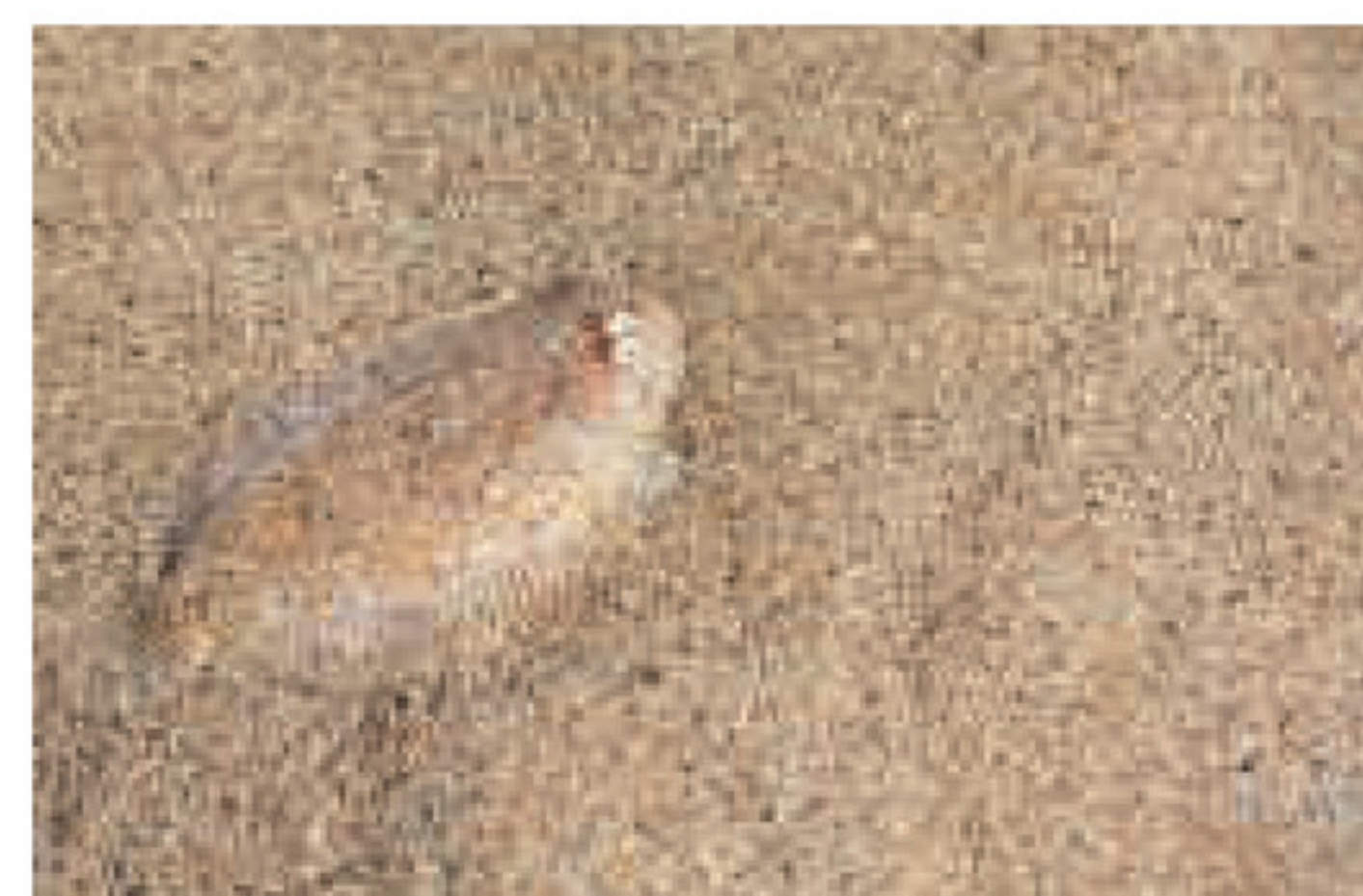
3 A sable grasshopper looks dangerous (but isn't).



4 A leopard tortoise protects itself with a shell.



5 A scorpion has a poisonous sting.



6 A common sole (fish) is camouflaged.

KNOWLEDGE

1

Figure 9 shows a trout.

What two adaptations does a trout have to reduce its resistance when moving in the water?

fig. 9 A trout.

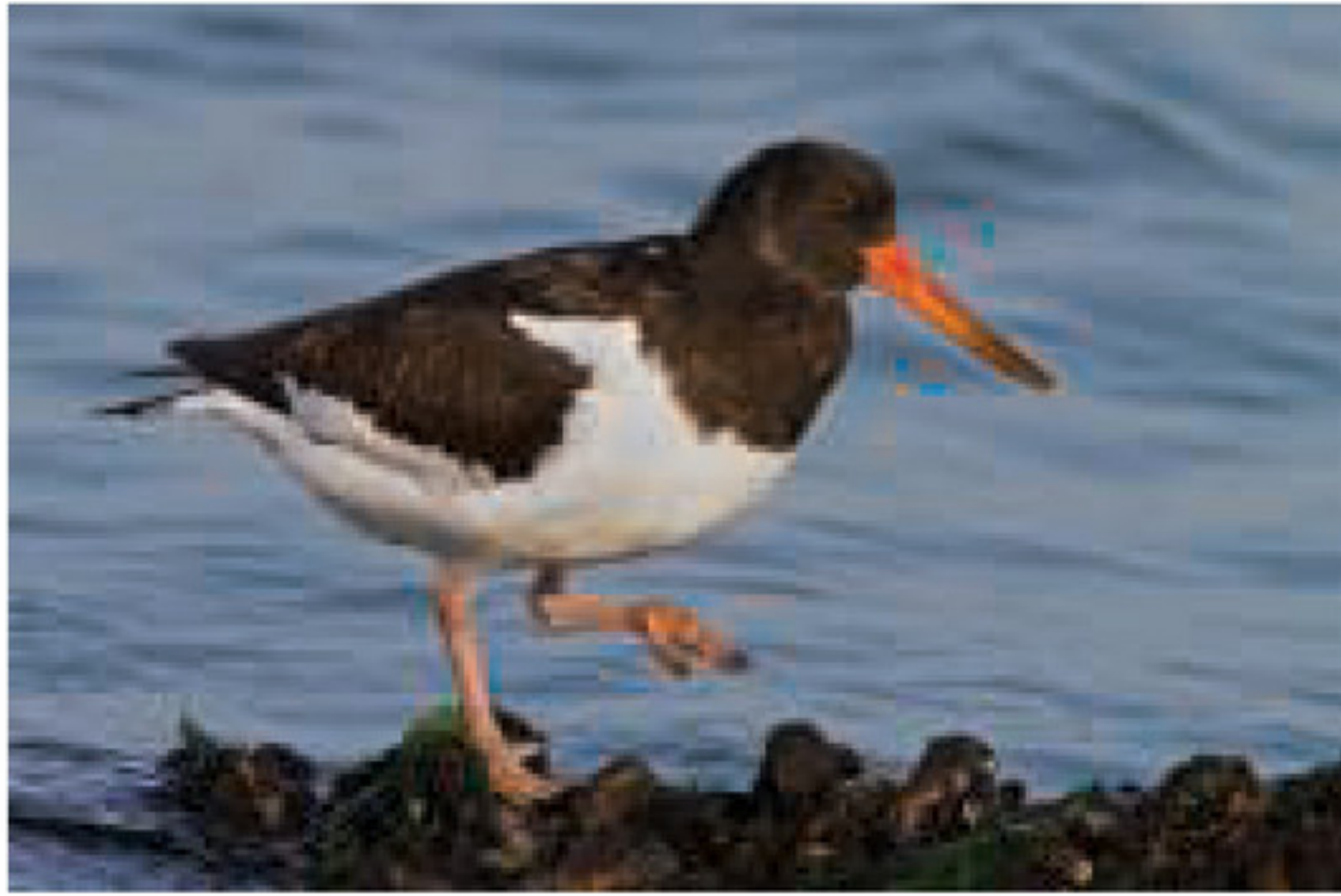
2

Figure 10 shows three bird species.
Write down the type of beak and the food that belongs to it next to each bird.

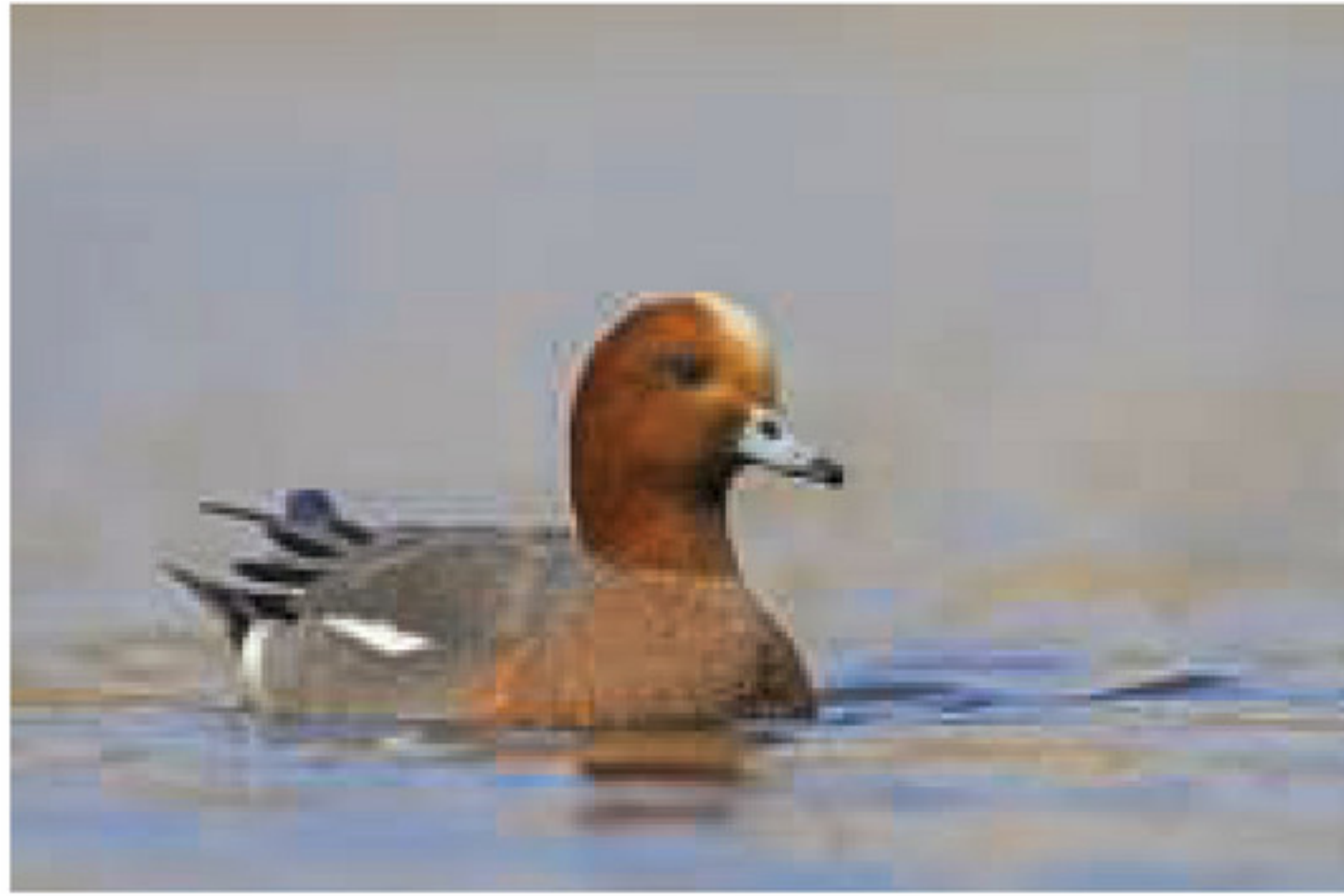
fig. 10



1 eagle-owl:
.....



2 oyster catcher:
.....



3 widgeon:
.....

3

Have a good look at the legs and the way animals walk in figure 11.
Write down next to each animal whether it is a plantigrade, digitigrade or unguligrade.

fig. 11



1 baboon:



2 zebra:



3 lion:



4 cow:

4

Giant hogweed is a dangerous plant that is common in the Netherlands. If you touch giant hogweed you can get blisters on your skin. Contact with your eyes can result in blindness. Fortunately, it sticks out: giant hogweed can reach a height of 2 to 4 metres and its leaves are up to 1 m long.

- a Giant hogweed occurs on moist soil.
What characteristic shows this?
- b How does giant hogweed defend itself against damage from insects?

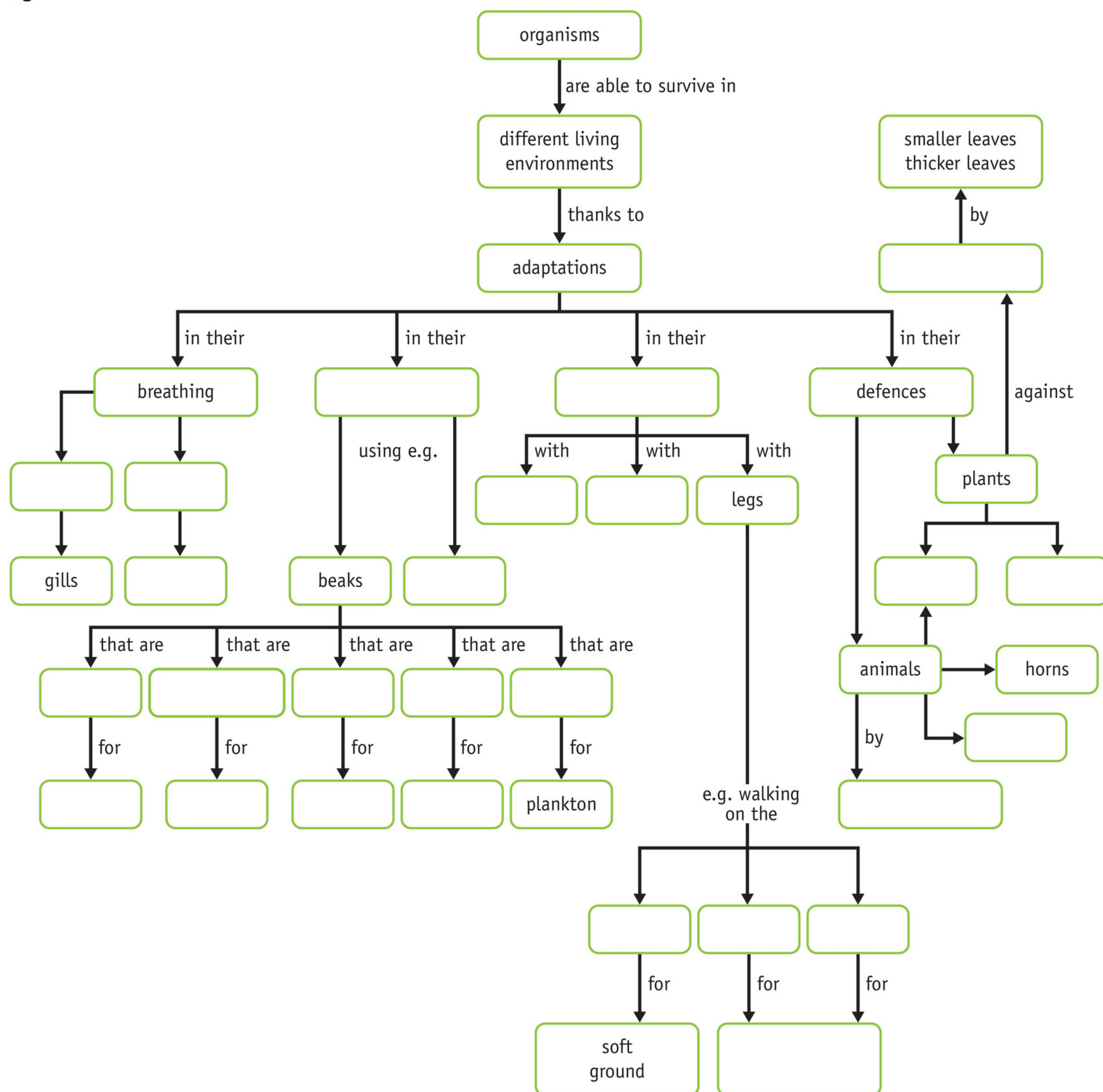
5

Summary

Fill in the word web in figure 12 with concepts from the Basics section. Choose between:
animals in the soil – beak – camouflage – cone-shaped – dehydration – feeding – filter – hook – hard surface – insects – land – lungs – moving – pointed – poison – prey animals – seeds – sole – spines (2×) – tail – toe – top – tweezer-shaped – water – wing.



fig. 12



INSIGHT

6

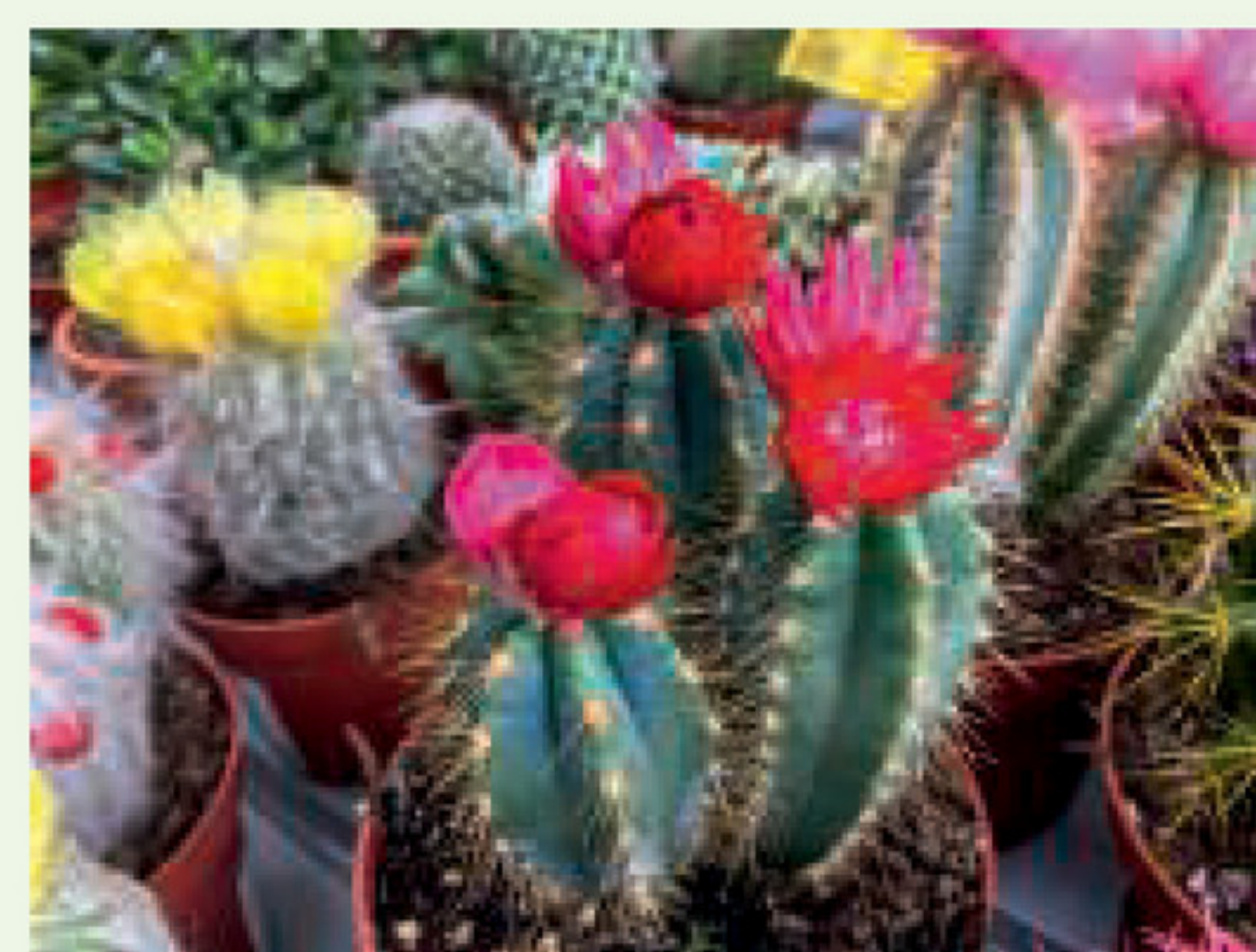
Read the text on 'Cacti'.

- a** Desert animals love eating juicy cactus stems.
What adaptation does a cactus have to stop animals gnawing at it?
- b** A cactus may go through periods of several months during which not a single drop of rain falls.
What adaptation does a cactus have to let it survive these periods?
- c** It does not rain very often in deserts.
What adaptation does a cactus have to let it make the most of a rain shower? Explain your answer.
- d** What two adaptations does a cactus have to prevent it losing moisture? Explain your answer.

fig. 13

Cacti

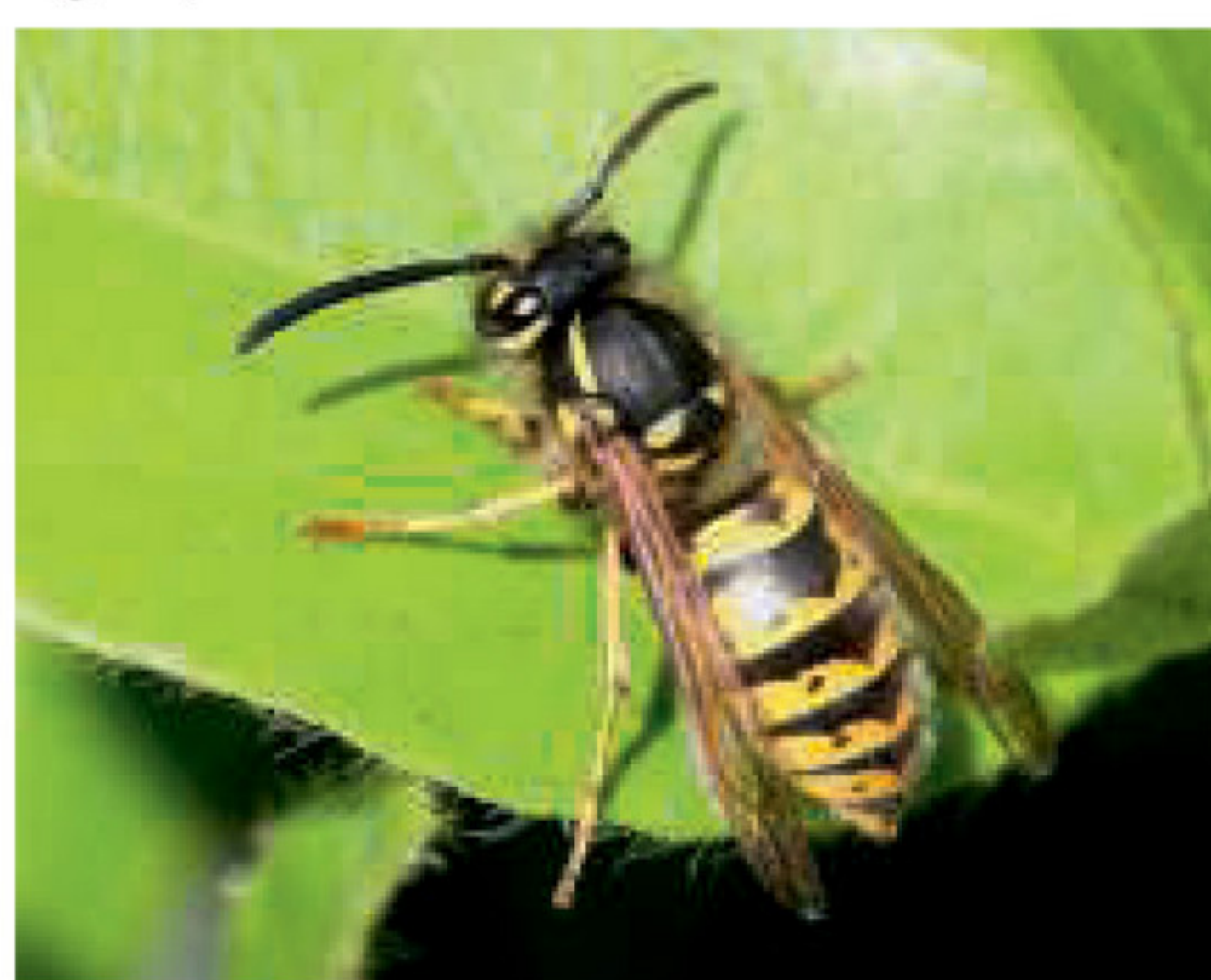
Cacti are plants that can withstand lengthy droughts. They grow in warm climates. Cacti have extensive root systems underground. The stems are thick and contain special tissues that water can be stored in. The leaves are shaped like spines or stiffened hairs. Flowers can appear between the spines or hairs.



7

Figure 14 shows three organisms that defend themselves against attackers. Which body part (or parts) do the animals use to defend themselves? Also state how the animal is defending itself and against what.

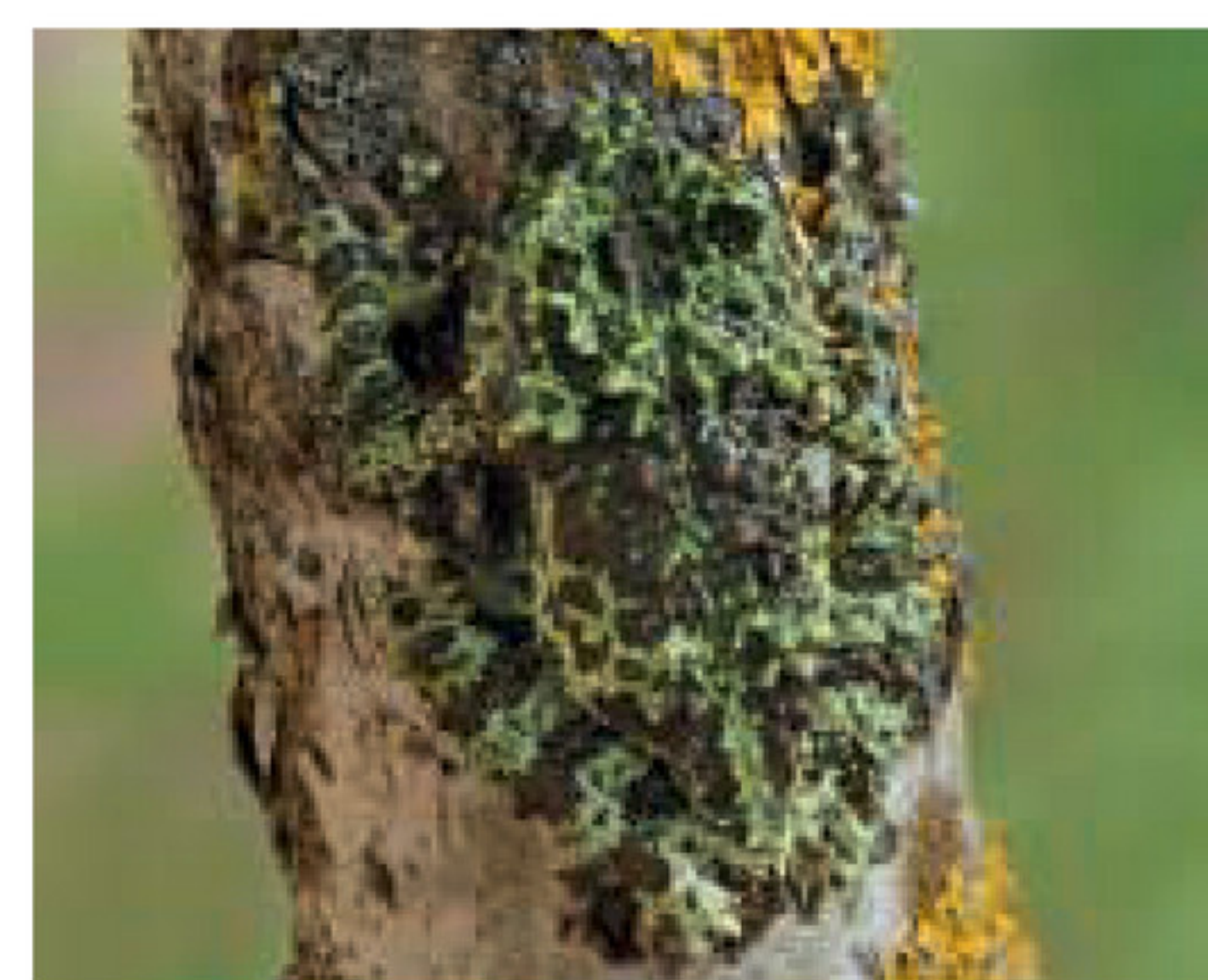
fig. 14



1 wasp



2 musk ox



3 tree frog

8

- a** Animals that live in water have streamlined bodies. This reduces their resistance in the water.
What is the advantage of this?
- b** Moles live underground (see figure 15).
Explain why a mole also benefits from a streamlined shape.

fig. 15 A mole.



9

The legs of animals are adapted to the ground they walk on.

- a** In which mammals is the resistance from the ground lowest: plantigrades, digitigrades or unguligrades? Explain your answer.
- b** Explain why the legs of a cow are not suitable for living on the loose sand of a desert.

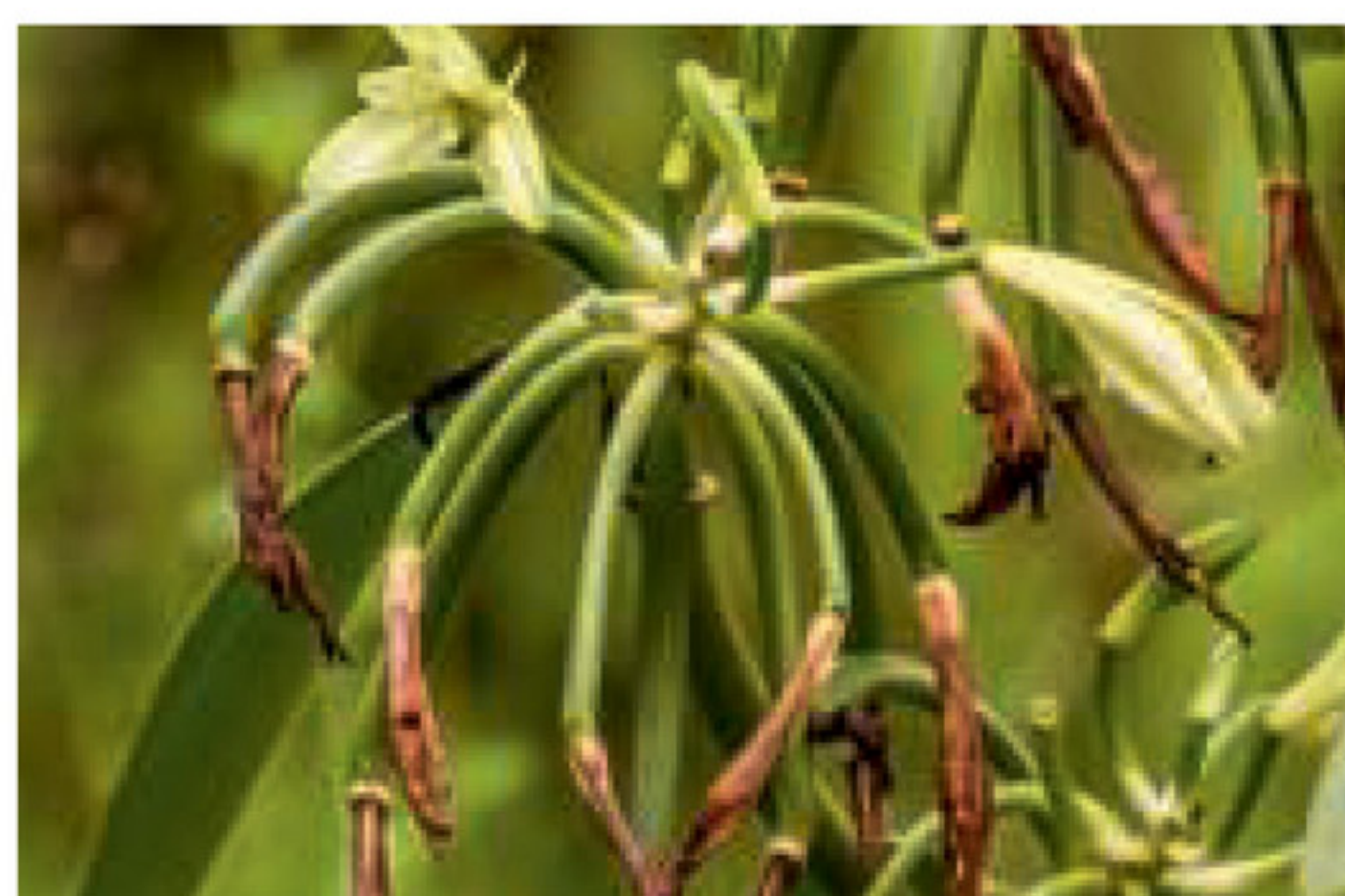
10

- a** You may come across samphire along the coast of Zeeland (see figure 16.1). Samphire is a plant that grows in salty environments (such as by the Wadden Sea, for example). Is the structure of samphire similar to that of land plants from dry environments, or to land plants from damp environments? Explain your answer.
- b** Vanilla is used as a seasoning in many sweet dishes, such as vanilla blancmange and ice cream. Vanilla is made from the fruits of the *Vanilla planifolia* orchid (see figure 16.2). The fruits of this orchid are vanilla pods. The vanilla orchid lives in the shade.
What adaptations will the leaves of the vanilla orchid have to help the plant live in the shade? Explain your answer.

fig. 16



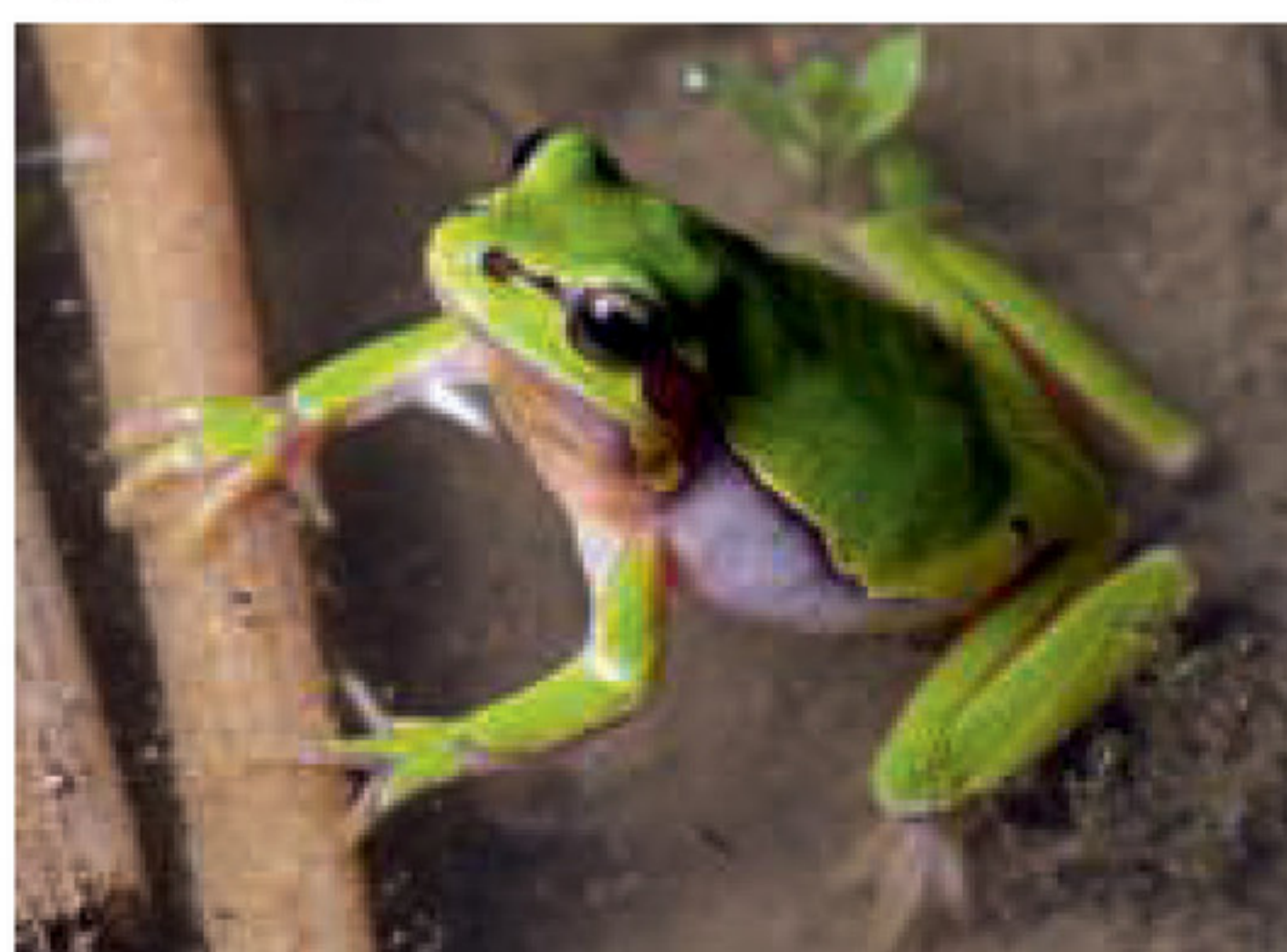
1 samphire

2 vanilla orchid (*Vanilla planifolia*).

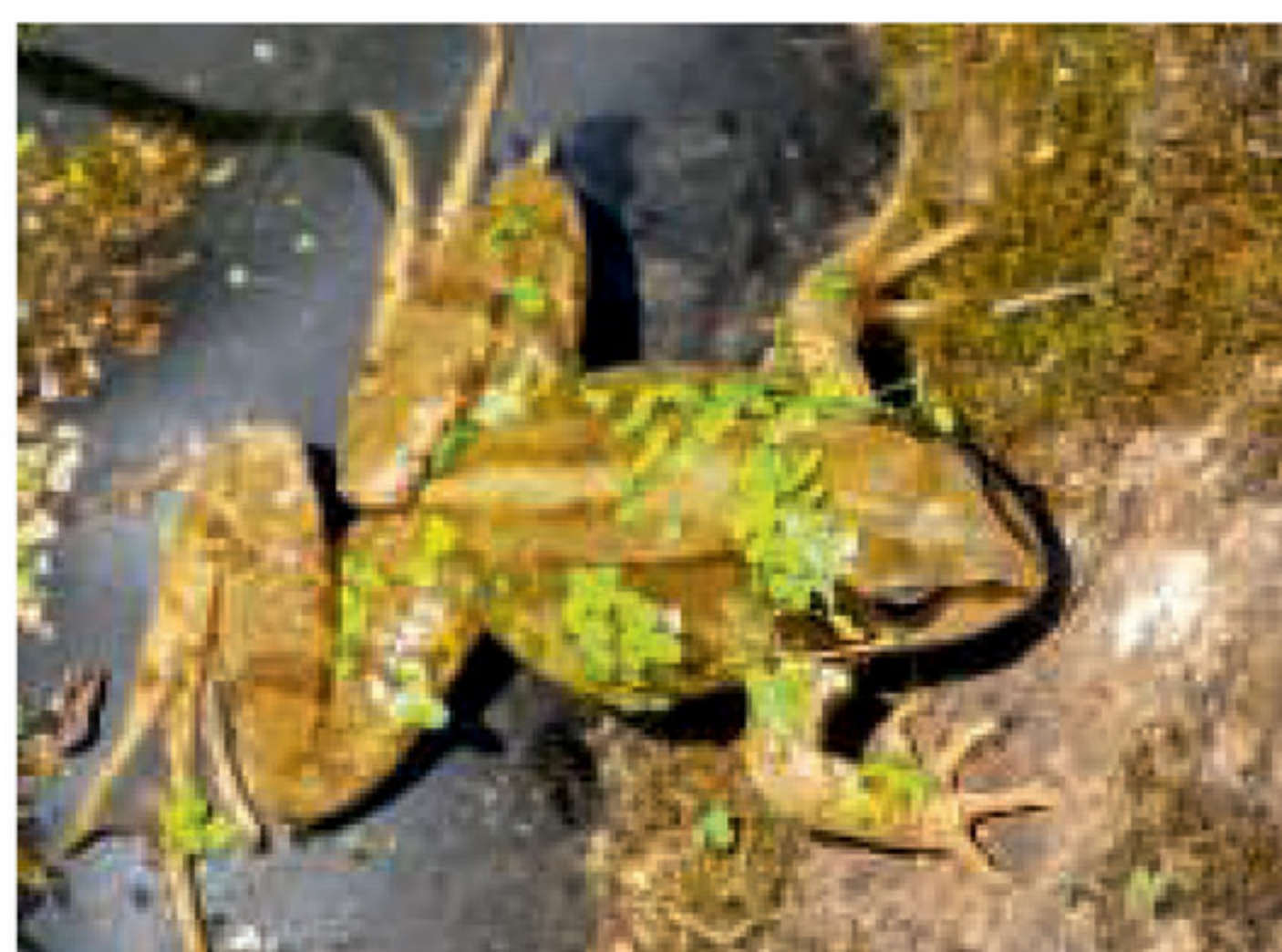
+ 11

Have a look at the structure of the frogs' bodies and legs in figure 17. Which frog lives in trees and which lives in the water? Explain your answer.

fig. 17 Frogs.



frog (a)



frog (b)

HOW IT FITS TOGETHER the living world

DANDELION

The dandelion is a master in survival thanks to its many adaptations. In the spring and summer, you see this flower everywhere: in meadows, gardens and even between paving tiles.

Each dandelion consists of a large number of small flowers (see figure 18.1). Bees are lured to the flowers by the yellow colour and the nectar (food). In exchange for the nectar, the bee pollinates the flower (fertilisation). When the small flowers have been pollinated, the flower closes (see figure 18.2). Each flower then develops a piece of fluff with a tiny fruit. The flowers are closed up so these fruits are protected against damage by insects. When the fruits are ripe, the flowers open. The wind then disperses the fluff. New dandelions grow from the seeds in the fruits.

Another of the dandelion's survival strategies is the leaf rosette. This is a closed ring of leaves, close to the ground, which keeps away other plants.

Dandelions are pretty tough. They produce a long root that goes deep into the ground. This allows the plant to be firmly anchored in the soil. If you pull on the plant, it breaks off just above the root. The root can grow back into a new plant.

fig. 18 Adaptations of the dandelion.



1 A dandelion consists of many small flowers.

2 The flower of the dandelion (1) closes after pollination by bees (2). When the fruits are ripe, the flowers open up again (3) and the fluff is dispersed by the wind.

12

Read the text about the “Dandelion”.

The dandelion has various adaptations for reproduction and defence.

- Describe four adaptations and say what their functions are: reproduction or defence.
- In dry soil, the root of a dandelion is long and not branched.
What shape would the root have in moist soil? Explain your answer.
- Explain how a leaf rosette keeps other plants away.

 Go to the *Flash cards* and the *Test yourself* section.

How it fits together

FROM POO TO TWIGS

You can only see it if you look carefully. A stick insect blends completely into its environment. Its shape and colour look exactly like a twig.

You might think that this would mean it has no predators, yet stick insects sometimes do end up in a bird's stomach. For most insects, it is the end if they get eaten by a bird, but stick insects are a little bit different.

Scientists have found out that the eggs of a stick insect can survive a bird's stomach. They saw this in the brown-eared bulbul, an insect-eating songbird that can be found in Japan (and elsewhere). A while after the bird had eaten the eggs of a stick insect, it excreted the undigested remains. The droppings contained unharmed stick insect eggs. Some of them hatched as normal.

In the wild, brown-eared bulbuls often eat stick insects so it is possible for stick insect eggs to be dispersed this way. Survival is not guaranteed in all birds' stomachs. In a previous study, chickens and quails ate stick insect eggs. Out of those, only one in a thousand eggs survived the journey through the beak and bird's stomach.

Baby stick insects that come out of the undamaged eggs can immediately walk away on their six legs. The stick insects grow in stages by shedding their skin. Each time they shed their old armour, they grow a little bit. They eat the old, empty skin or leave it behind. A stick insect is only fully grown after shedding six to nine times. In about 40% of the species, wings unfold after the last shedding, which they can really use to fly with. Some species have spines on the body. There are even stick insects with legs that look like leaves.

fig. 1 A kookaburra also eats stick insects.



EXERCISES

1

- a** What type of beak would you expect the brown-eared bulbul to have? Explain your answer.
- b** How do stick insects defend themselves against the brown-eared bulbul?
- c** Figure 8.3 (Basics 6) shows the adaptations of a sable grasshopper against its enemies. Just like a stick insect, the sable grasshopper tries to avoid getting eaten. The ways the two insects do that are different. Explain what the difference is between the sable grasshopper's defence and the stick insect's.

2

- a** Does the stick insect undergo a metamorphosis during its lifecycle? Explain your answer.
- b** What physical development takes place in all stick insects?
- c** What motor development takes place in winged stick insects?

3

- a** Is a stick insect that has been eaten and is in the stomach of a bird living, dead or non-living? Explain your answer.
- b** Is a stick insect in an egg that has been eaten and is in the stomach of a bird living, dead or non-living? Explain your answer.

4

- a** A stick insect cannot walk or fly very far. Thanks to the brown-eared bulbul, though, its offspring can end up in a new living environment. Explain how.
- b** Some birds eat berries (small fruits with seeds). The seeds are excreted elsewhere. Explain that this is important for the lifecycle of the berry bush. First, think of what would happen if all the berries fell on the ground under the bush.

5

Stick insect eggs come in all shapes and sizes (see figure 2.1). Some stick insect eggs have an adaptation that also appears in castor beans, the seed of the castor oil plant (see figure 2.2). This adaptation is called an elaiosome.

- a** Take a look at figure 2. Which part is the elaiosome?
- b** Ants take the seed with elaiosome to their nests. Explain why they do this.
- c** Adaptations in organisms often involve one or more life processes. The elaiosome is important for a life process of the stick insect and the castor oil plant. Which life process is that? Explain your answer.
- d** The seed leaves of a castor bean contain nutrients for the seedling. A young stick insect does not need this kind of food reserve. Give an explanation for this.

fig. 2 Adaptations in stick insects and castor beans.



1 various stick insect eggs



2 castor bean with elaiosome

7 The importance of photosynthesis

LEARNING OBJECTIVE

1.7.16 You can explain that many fuels and raw materials exist thanks to photosynthesis.

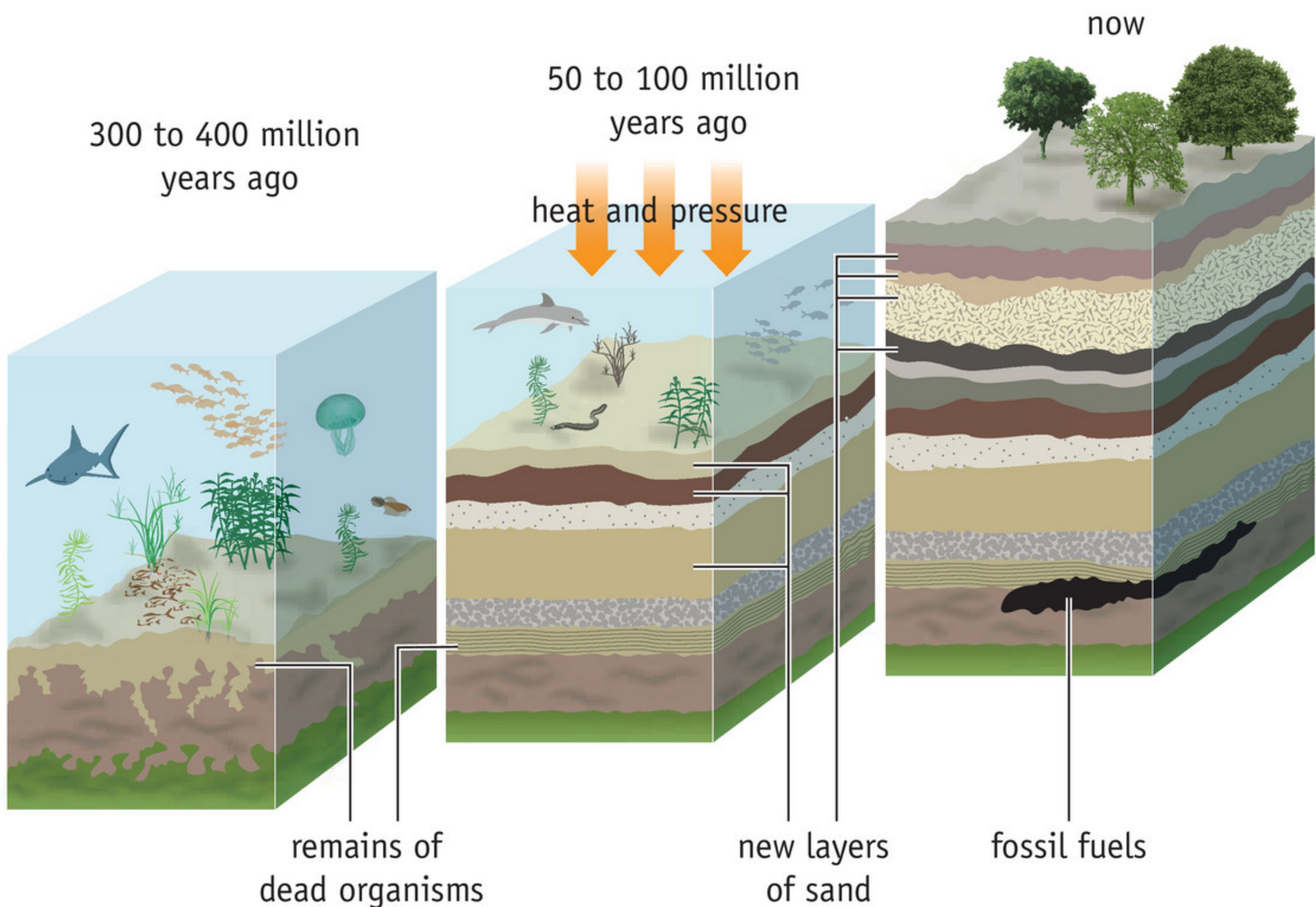
TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	1.7.16
Remembering	
Understanding	1a
Using	1bcde, 2, 3
Analysing	

Plants can make glucose by photosynthesis. The plant can use glucose to make other substances. People depend on raw materials that were created thanks to photosynthesis.

FUELS

Natural gas, petroleum and coal are commonly used fuels. Petroleum is used to make petrol for cars. Many homes still have boilers that use natural gas. Coal is mainly used as fuel in power plants. These fuels were formed from the remains of dead organisms that ended up on the sea bed millions of years ago. There they got compressed more and more by new layers of sand. The high pressure and heat changed the remains into coal, petroleum and natural gas. These are called **fossil fuels** (see figure 1). Fossil fuels originated from organisms that could live and grow thanks to photosynthesis.

fig. 1 Fossil fuels.

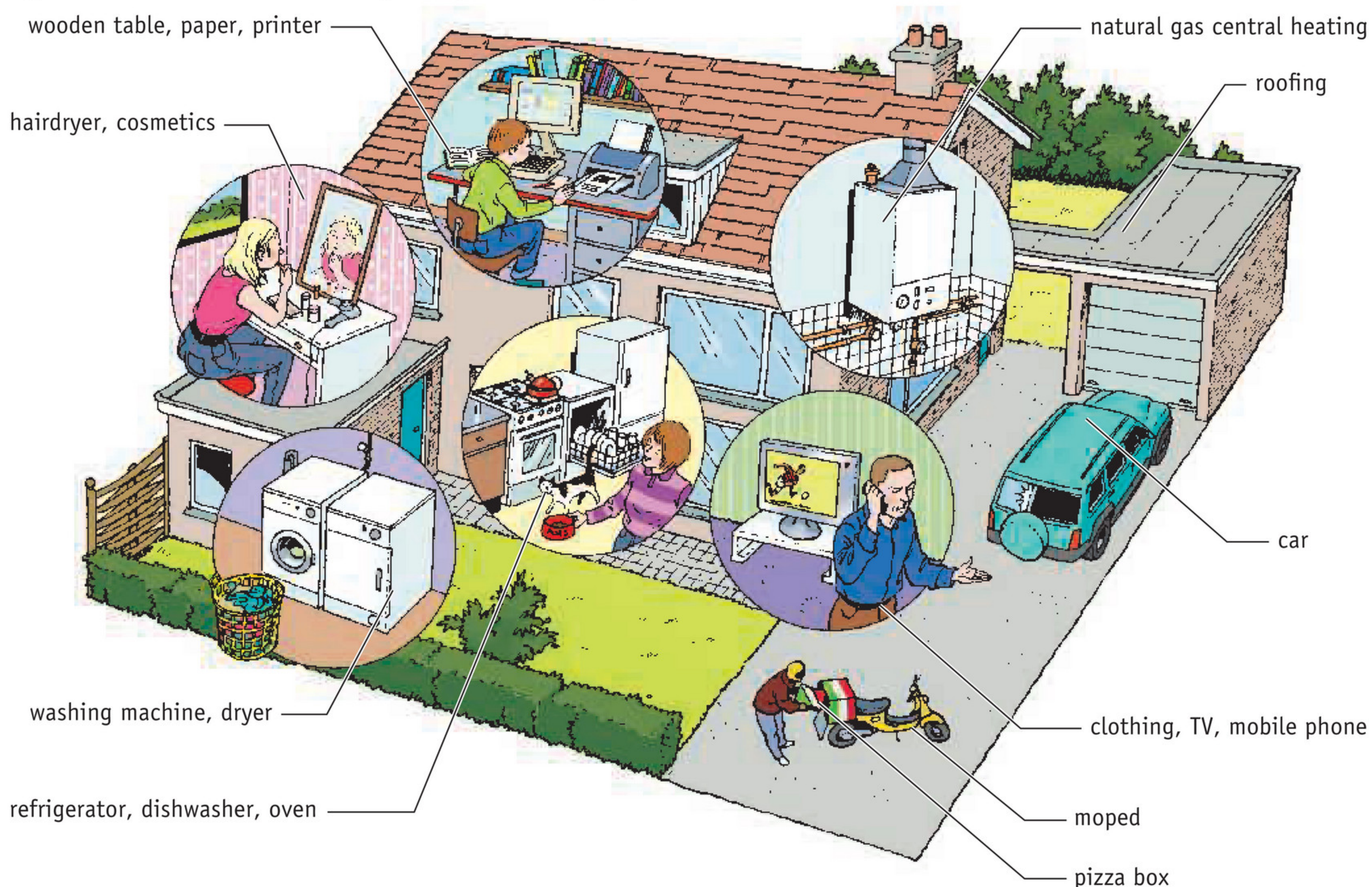


RAW MATERIALS

Photosynthesis has also played a part in most of the raw materials. **Raw materials** are the materials that products are made of. Many items are made at least partly out of plastic – take your mobile phone or a TV, for instance.

Plastics are made from petroleum. A lot of clothing is made of plastics such as polyester. Petroleum is also used to make other raw materials. You can find these materials in all sorts of products, such as cosmetics and roofing (see figure 2).

fig. 2 Fuels and raw materials that photosynthesis has played a role in.



Other raw materials that people use come from plants or animals that are alive now (see table 1).

Table 1 Raw materials from plants and animals.

Raw material	From...	What is it made from?	What is it used for?
Bamboo	plant	wood of the bamboo plant	clothing
Bonemeal	animal	crushed bones of animals from abattoirs	glue, gelatine
Wood	plant	logs (tree trunks)	paper, furniture, toys
Cotton	plant	the fluff of the cotton plant	clothing
Leather	animal	skin of e.g. a cow, sheep, pig or goat	shoes, bags, belts
Linen	plant	stems of flax plants	clothing
Tencel	plant	wood of the eucalyptus tree	clothing
Wool	animal	fur of a sheep, goat or llama	clothing, rugs
Silk	animal	cocoon of the silkworm	luxury clothing

EXERCISES

1

- Photosynthesis is important for many products that people use.
- a Explain how most of a pair of cotton jeans was produced by photosynthesis.
 - b Explain how leather shoes were ultimately made by photosynthesis.
 - c Explain how plastic toys were ultimately made by photosynthesis.
 - d Find four objects in your own bedroom that were ultimately made by photosynthesis. Briefly explain how.
 - e The bulk of the electricity from a wall socket can be generated thanks to photosynthesis. Explain why.

2

- Your classroom is full of furniture and equipment. Various raw materials were used to make these items of furniture and pieces of equipment.
- In groups of two, make a list of at least eight objects.
 - Next to each object, write down what it was made of.
 - Say whether this raw material comes from a plant or an animal.
 - For each object, state whether it was ultimately made by photosynthesis.

3

- You will have various clothing items in your cupboard such as trousers, shirts and sweaters. Most clothing items have a label that says what they are made of. The table lists a few clothing items.
- Have a look at the label to see what raw material the clothing item is made from.
 - Also write down whether that raw material comes from a plant or an animal.
 - In the fourth column, say whether these animals/plants lived long ago or just recently.

Clothing item	Raw material	Plant or animal?	Long ago or nowadays?
Coat			
Dress			
Shorts			
Shirt			

Jeans			
Sweater			
T-shirt			

 Go to the *Flash cards*.

8

Young that stay and young that go

LEARNING OBJECTIVE

1.8.17 You are able to name the characteristics of altricial and precocial animals.

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	1.8.17
Remembering	1ab
Understanding	
Using	1cde, 2
Analysing	

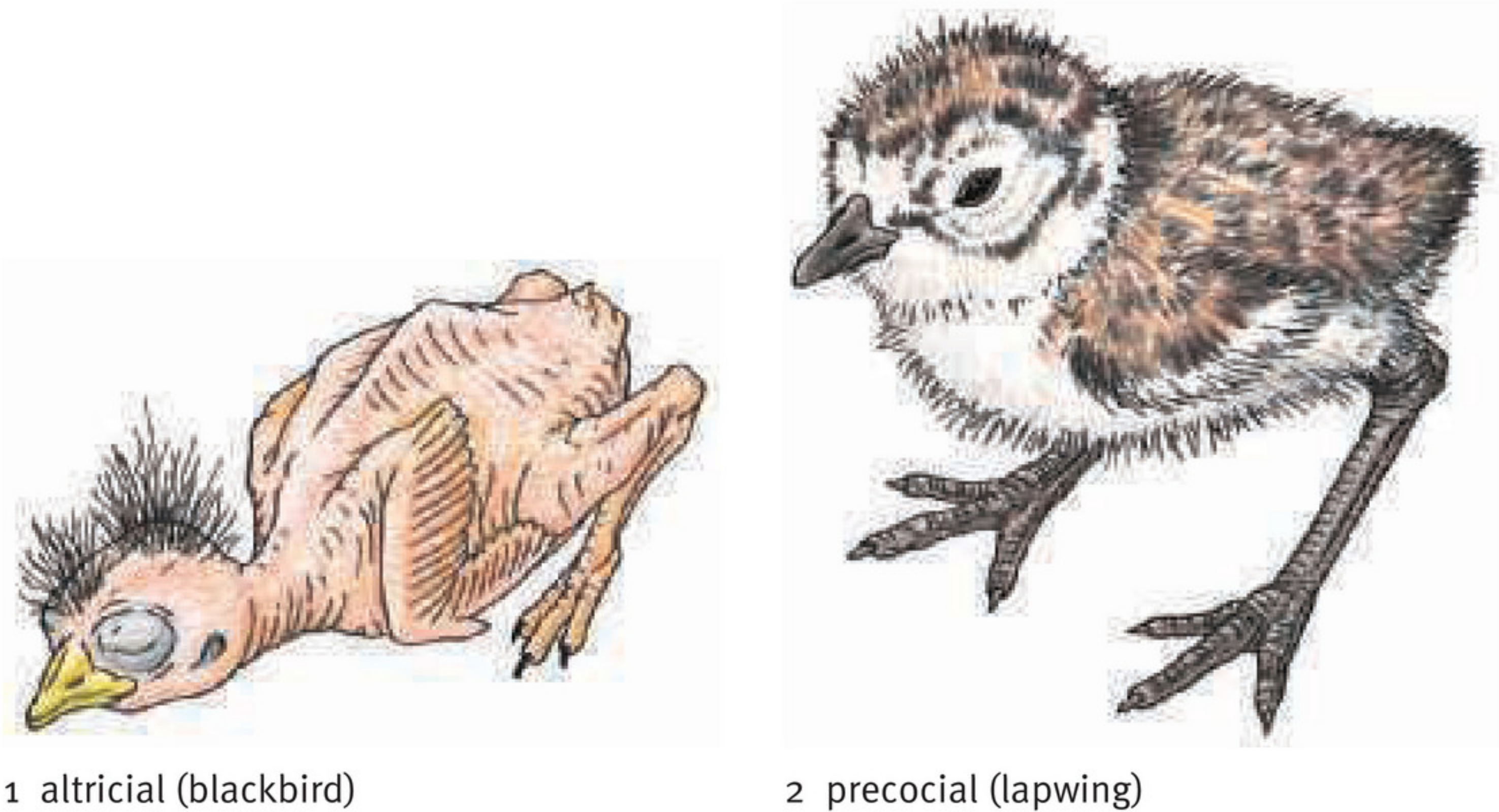
You may perhaps have seen a nest of young birds. The young were probably naked and helpless in the nest. In other types of animals, the young can stand up shortly after birth.

BIRDS

Birds that are helpless after hatching are said to be **altricial** (see figure 1.1). Blackbirds are blind during the first few days after hatching, for instance. They do not have feathers yet and cannot stand on their own legs. Altricial birds remain in the nest for several weeks and are cared for by the parents during that time. The young of all songbirds stay in the nest for some time after hatching.

There are other types of birds whose young leave the nest very soon after hatching. They can see as soon as they hatch and they can walk around just an hour or so later. They are covered in downy feathers (see figure 1.2). These birds are said to be **precocial**. The young of birds that live and brood on the ground or on water do not usually remain in the nest.

fig. 1 Young birds.



1 altricial (blackbird)

2 precocial (lapwing)

Animals that leave the nest early are further developed when they are born, but they do not mature faster. A duckling is very soon able to look for food itself, for instance, whereas a blackbird chick has to be fed by its parents for a few weeks. The young blackbird grows so fast, however, that it will have developed further than the duckling by the time it is a few weeks old. When the young blackbird leaves the nest a couple of weeks later, it can already fly. The duckling can only do that much later. Young blackbirds have already long become independent while the ducklings are still swimming around after their mother.

MAMMALS

The terms altricial and precocial can be used for mammals too. New-born mice are helpless and blind (see figure 2.1). A mouse is therefore altricial. A baby giraffe, though, is able to stand just five minutes after it is born and it is capable of following its mother around shortly after that (see figure 2.2). A giraffe does not make a nest and a baby giraffe is already well developed when it is born. So giraffes are precocial.

fig. 2 Young mammals.



1 altricial (mouse)



2 precocial (giraffe)

EXERCISES

1

The young of altricial animals and precocial animals are different.

- a What do the young of altricial animals look like shortly after birth?
- b What do the young of precocial animals look like shortly after birth?
- c Birds that nest in trees are often altricial. Birds that nest on the ground are often precocial. Explain why. Use the phrase 'chance of survival' in your explanation.
- d Explain why a baby mouse is naked, helpless and blind but still has a good chance of survival.
- e Explain why a baby giraffe would have less chance of survival if it was altricial.

2

Five animals are listed below.

Write down next to each animal whether it stays in the nest or leaves it. You can look things up on the Internet.

- | | |
|---------------------------------|------------------------------|
| 1 a kitten (the young of a cat) | <i>altricial / precocial</i> |
| 2 a puppy (the young of a dog) | <i>altricial / precocial</i> |
| 3 the young of a guinea pig | <i>altricial / precocial</i> |
| 4 the young of a hamster | <i>altricial / precocial</i> |
| 5 a foal (the young of a horse) | <i>altricial / precocial</i> |

 Go to the *Flash cards*.

Learning how to do research

1

MAKING DRAWINGS

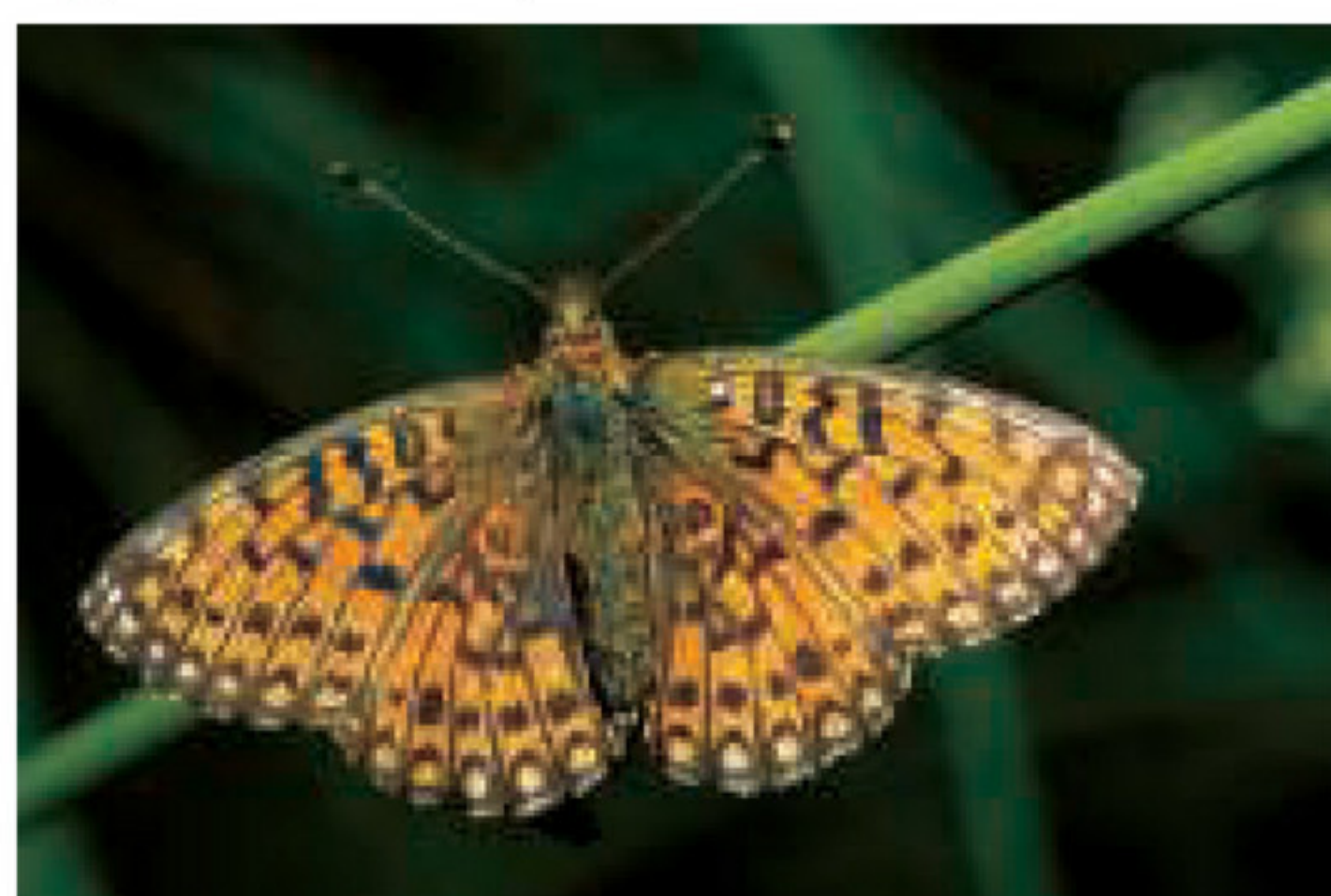
► Basics 1 | ► Learning objectives 1.O.18, 1.O.19 and 1.O.20 | ► Practical activities 1, 2, 3 and 9

TRUE-TO-LIFE AND SCHEMATIC

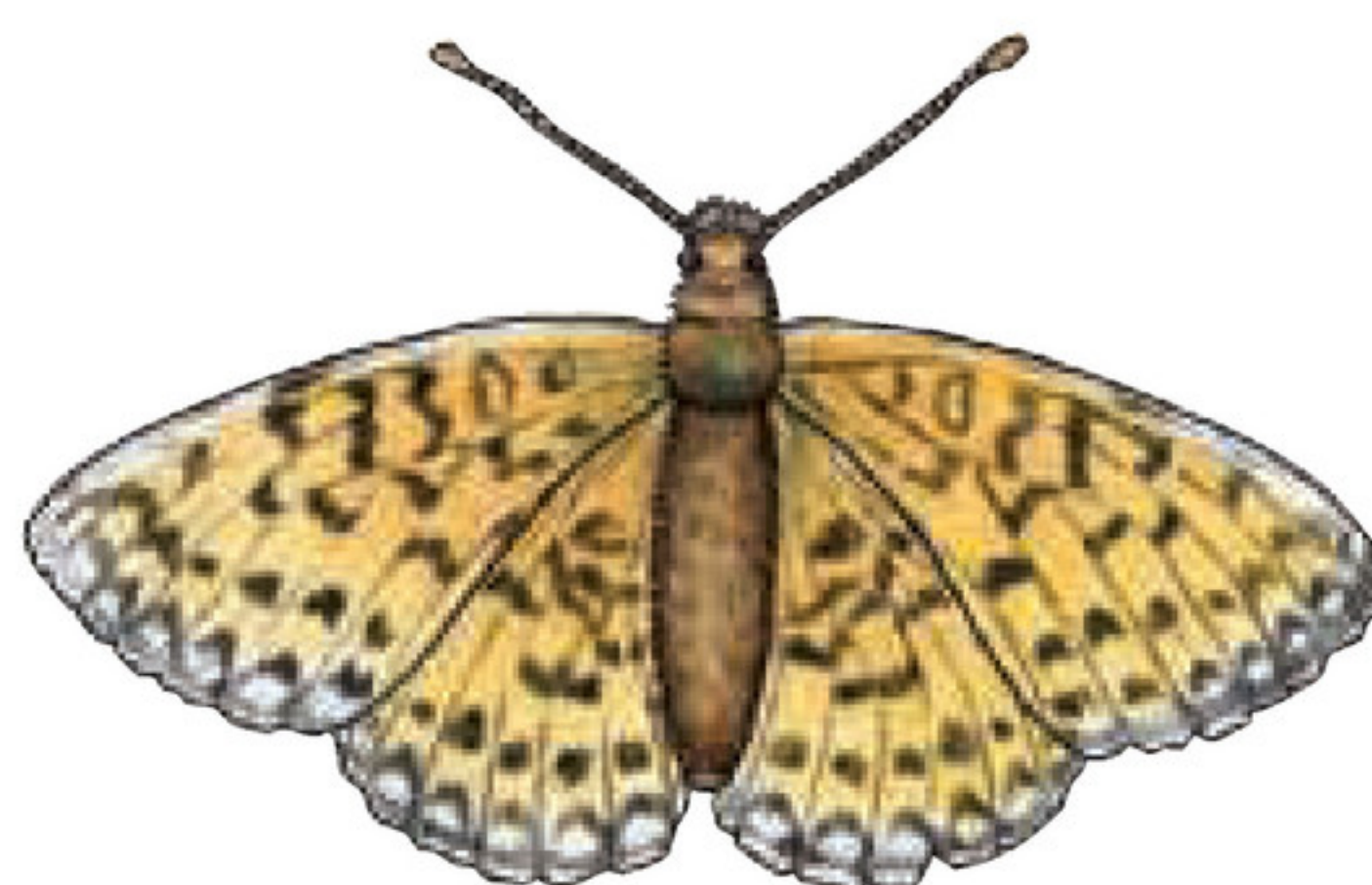
In biology, you examine organisms as accurately as possible. The best way to do this is to make drawings of them. When you are drawing an organism, you must naturally look very closely at it.

Two kinds of drawings are used in biology: true-to-life drawings and schematic drawings. You put in all the details as accurately as possible in a **true-to-life drawing** (see figure 1.2). In a **schematic drawing**, you leave out the details and only draw in the most important features (see figure 1.3).

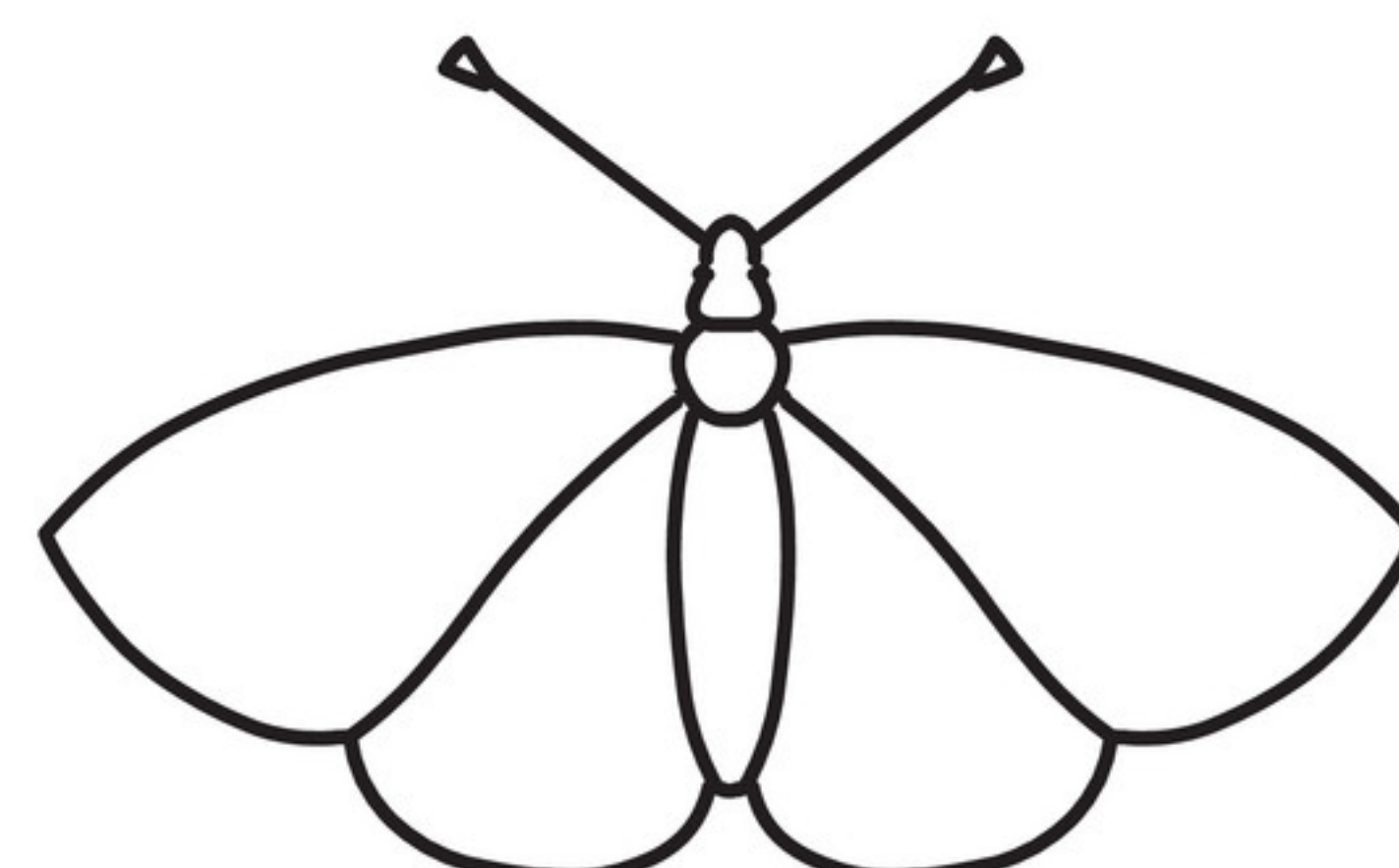
fig. 1 A butterfly.



1 photo



2 true-to-life drawing



3 schematic drawing

VIEWS AND CROSS-SECTION

You can make a drawing of the **external view** of an organism (see figure 2.1). You can also cut through an organism first before drawing it. There are various ways of making such a cross-section (see figures 2.2 and 2.3). In a **longitudinal section**, you cut the organism or object along its length. In a **transverse section**, you cut the organism or object across its width. In a section, you only draw the plane of the cut, not any depth that you might see.

fig. 2 A pencil (schematic).



1 external view



2 longitudinal section



3 transverse section

DRAWING RULES

Figure 3 lists the drawing rules that you should follow when making drawings in biology.

fig. 3

Drawing rules

- | | |
|---|---|
| <ol style="list-style-type: none"> 1 Make large drawings. Do not put more than two or three drawings on the same page. 2 Use a pencil that is not too soft (e.g. HB). 3 If you add colours, use coloured pencils (not pens). 4 Draw the outline first in thin lines and then add the various parts. You can make the lines clearer after that. 5 Draw what you see and not what your book says you ought to see. 6 Do not make your drawings too complicated. 7 Give your drawing a title, stating which organism or which part of an organism you have drawn. | <ol style="list-style-type: none"> 8 If you are making a schematic drawing, include the word “schematic” in the title. If you are drawing a cross-section, state whether it is a lengthwise (longitudinal) section or a crosswise (transverse) section. If you are drawing something that you have seen with a magnifying glass or a microscope, note down the magnification. 9 Add names to the parts you recognise. Place a horizontal line between a part and its name. 10 Work neatly! |
|---|---|

EXERCISES**1**

- a What is the difference between a drawing that is true to life and one that is schematic?
- b When an artist paints a portrait, is it a true-to-life drawing or a schematic drawing?
true-to-life drawing / schematic drawing

2

- a What can you draw in a schematic cross-section?
 - ☐ A external view
 - ☐ B details
 - ☐ C depth
 - ☐ D the plane of the cut
- b The drawing in figure 4 is a *transverse section / longitudinal section*.
- c Figure 5 shows a transverse section of a pencil. You can make such a cross-section of a pencil at various places along its length. Will all the cross-sections look the same? Explain your answer.

fig. 4

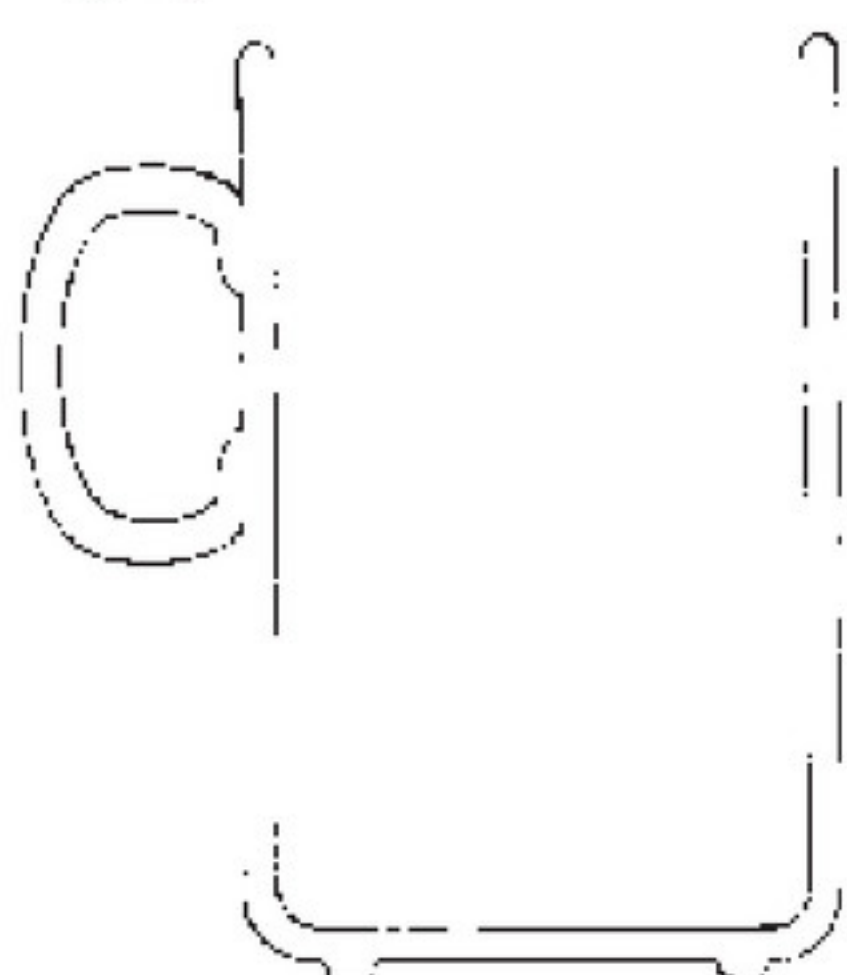


fig. 5



2

MAGNIFYING

► Basics 2 | ► Learning objective 1.O.21 | ► Practical activities 2 and 3

WORKING WITH A MAGNIFYING GLASS

In biology, you try to observe organisms yourself as far as possible. Some organisms are so small that you cannot see them with the naked eye. You can then use a magnifying glass (see figure 6). The best kind to use are ones that have a magnifying power of about 10 times. You have to hold the magnifying glass close to your eye. The object you are looking at has to be brought up to the magnifying glass, until you see a clear image (see figure 7).

fig. 6 Magnifying glasses.



fig. 7 Using a magnifying glass.



3

MAKING TABLES AND GRAPHS

► Basics 2 | ► Learning objectives 1.0.22, 1.0.23 and 1.0.24 | ► Practical activity 7

TABLE

Figure 8 shows you drawings of a germinating seed. Ten drawings have been made, on different days. You can measure the lengths of the root and shoot in each drawing. These measurements can be represented in a **table**. A table is a grid with rows and columns (see figure 9).

fig. 8 The germination of a seed and the growth of the seedling.

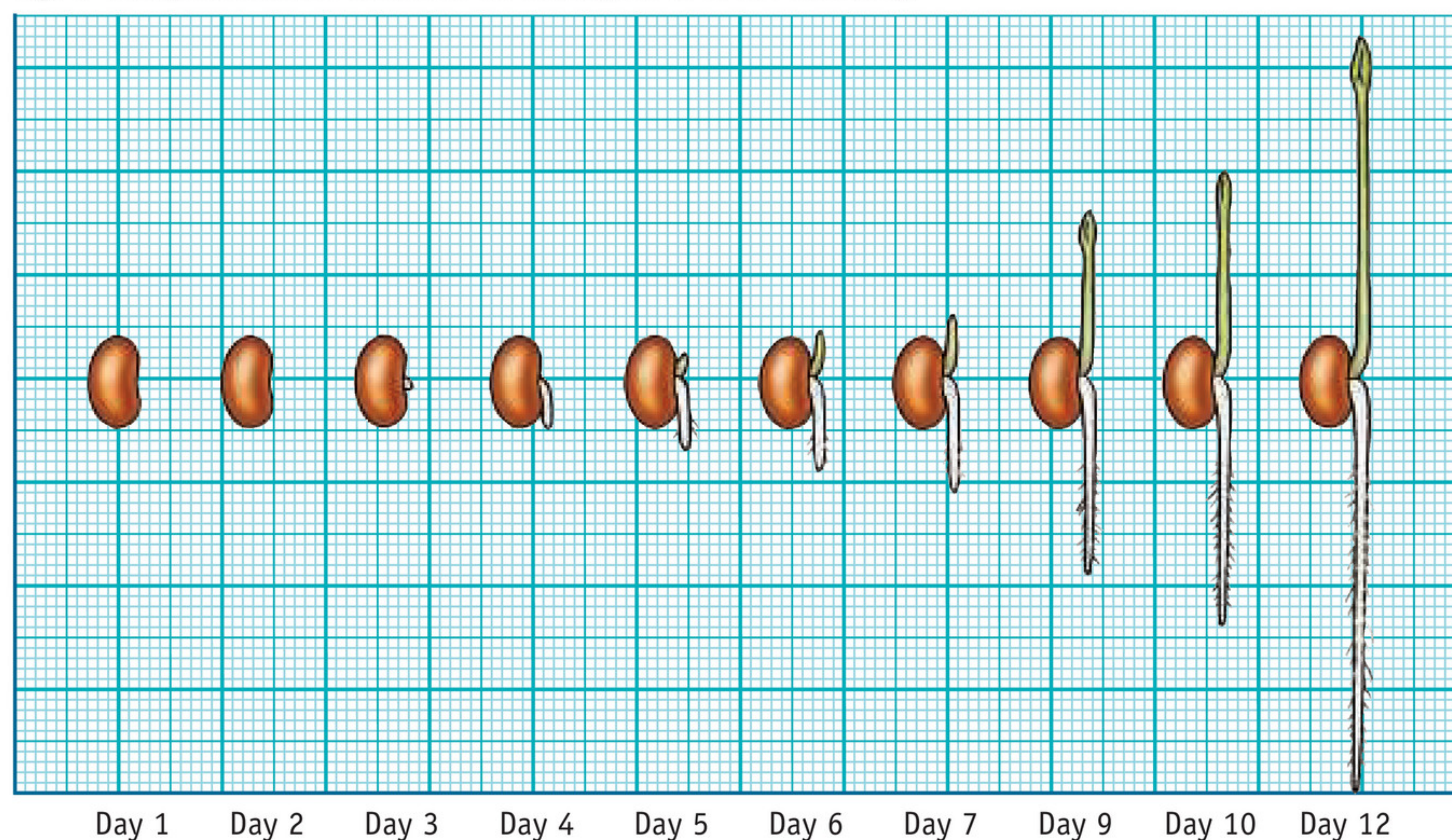


fig. 9 A table.

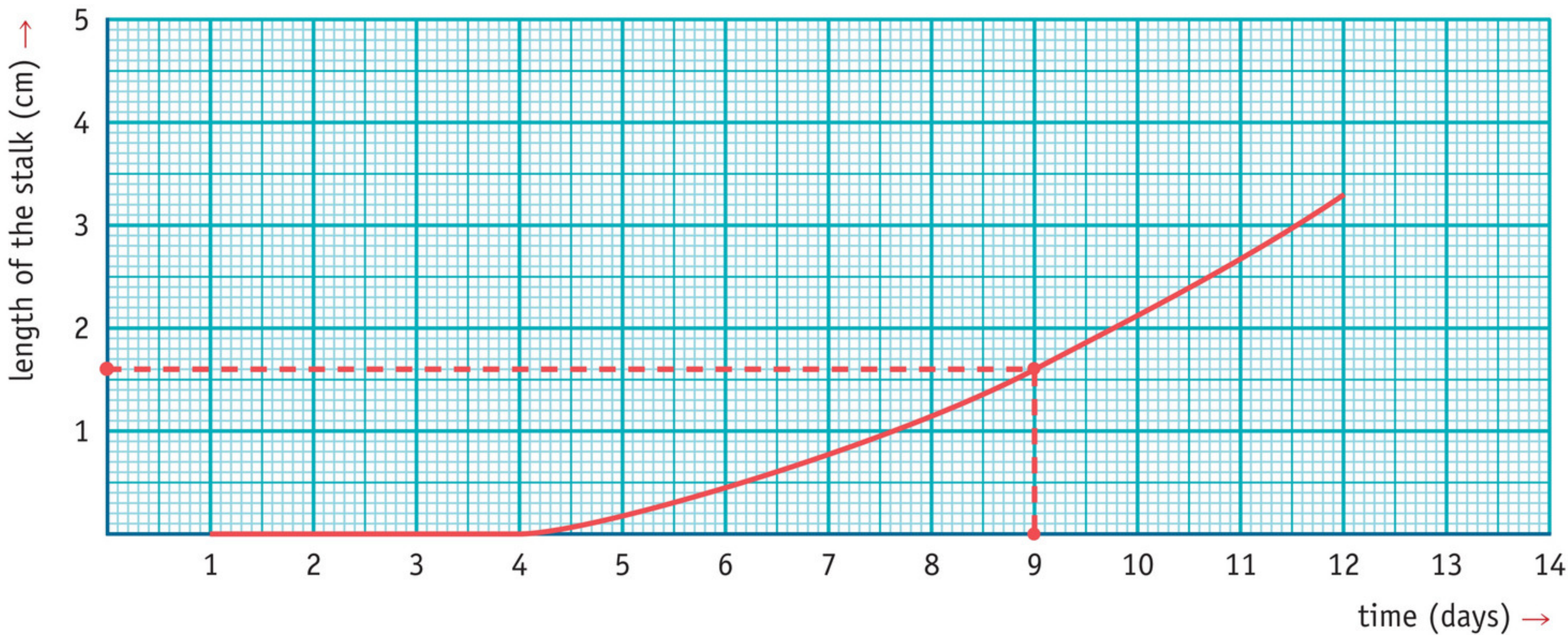
A diagram illustrating a 2D array structure. It consists of a grid of 4 rows and 2 columns. The word "columns" is written above the grid with two green arrows pointing down to the column headers. The word "rows" is written to the left of the grid with four green arrows pointing right to the row headers. The grid is composed of 8 cells in total, arranged in 4 rows and 2 columns.

GRAPH

You can also represent the growth of the shoot and root in a **graph**. A graph has two axes. The horizontal axis is called the **x-axis** and the vertical one is the **y-axis**. In figure 10, the x-axis gives the number of days, and the y-axis gives the length of the shoot.

The length of the shoot on Day 9 is shown as a point. The shoot was 1.6 cm long on that day.

fig. 10 Graph showing the growth of a shoot.



AVERAGE

If you want to know how much the shoot grows a day on average, you calculate the **mean**. Every day you measure how much the shoot has grown. You add these measurements up and divide the total by the number of days you have measured. In biology, you often calculate means (averages).

EXERCISES

3

Figure 8 shows a bean germinating. Measure the length of the radicle and the length of the shoot in each drawing. Write the lengths down in the table. The first three days have already been filled in for you.

Days	Length of the root	Length of the shoot
Day 1	0 mm	0 mm
Day 2	0 mm	0 mm
Day 3	1 mm	0 mm
Day 4	mm	mm
Day 5	mm	mm
Day 6	mm	mm
Day 7	mm	mm
Day 9	mm	mm
Day 10	mm	mm
Day 12	mm	mm

4

- a Figure 11 shows you some graph paper with two axes. You are going to plot the length of the shoot upwards on the y-axis, with the length of the root plotted downwards.
- Add scales to the x-axis and the y-axis.
 - Label to the x-axis and the y-axis stating what you are plotting on each axis. Do this as shown in figure 10.
 - In the top half of the graph paper, draw in points to mark the length of the shoot on each day. Use the data from the table in exercise 3.
 - Connect the points with smooth lines.
 - In the bottom half of the graph paper, draw in points to mark the length of the root on each day. Use the data from the table in exercise 3.
 - Again, connect the points with smooth lines.

fig. 11



- b** Have a look at the graph you made for the exercise.
What can you say now about the growth of the shoot and the root?

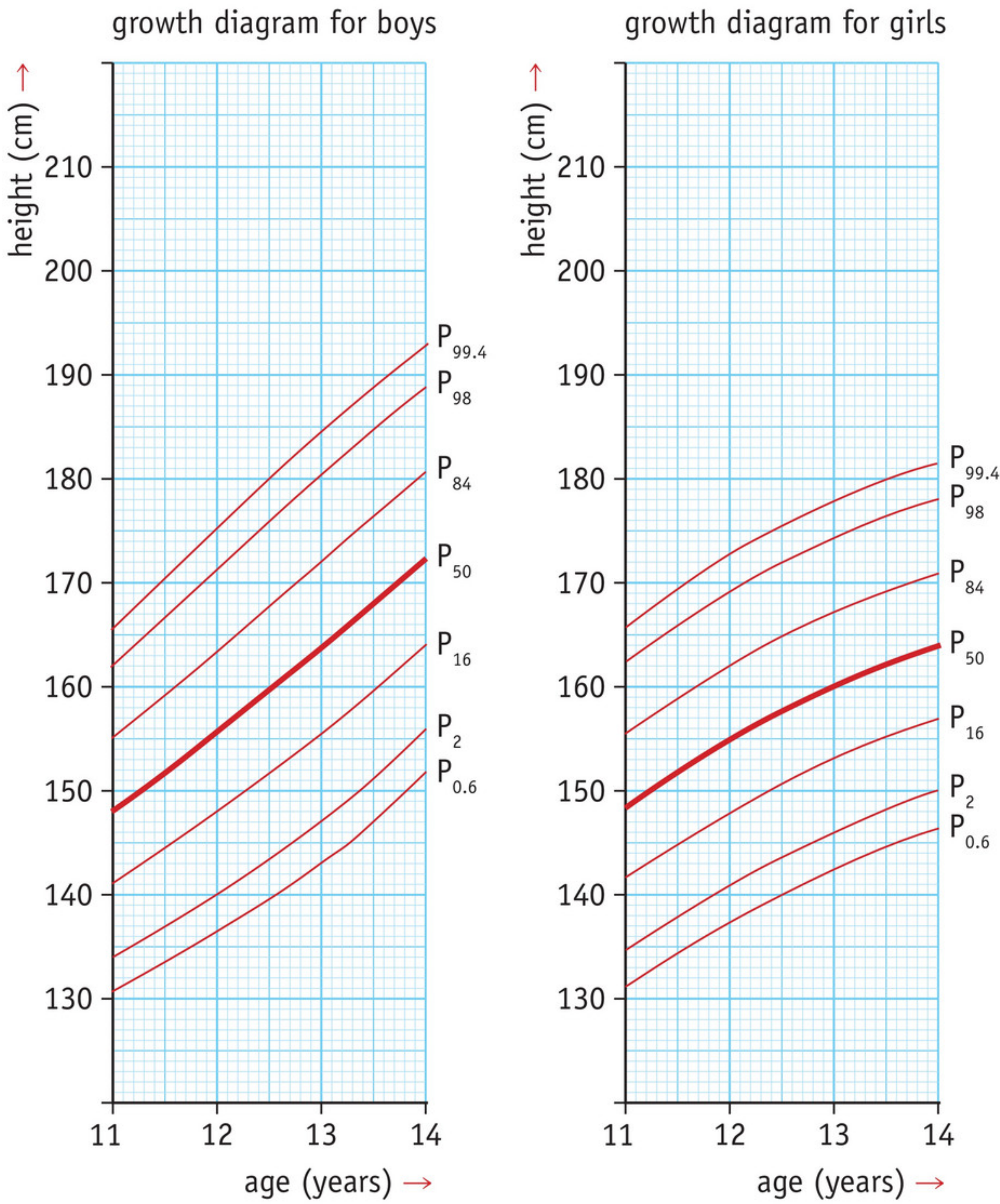
+ 5

Figure 12 shows two graphs, giving the heights of a group of boys and girls aged 11 to 14 from a certain city.

The percentiles are marked next to the lines, for example as P_{98} . In this case, it means that 98% of boys are below that line and 2% are above it.

- a** At what age have half of all girls reached 160 cm?
- b** What percentage of boys are taller than the P_{16} line?
.....
- c** At what age are 98% of boys taller than 140 cm?
.....
- d** It is important that you grow steadily. If the growth line suddenly starts going up more slowly, something may be wrong. If your height is below the P_2 line, this may also mean that something is wrong, although that is not necessarily the case if you are growing steadily.
Luke, aged 12, is 142 cm tall but growing steadily. Luke is afraid that he might have some kind of illness that means he is not growing enough. A school doctor looks at the graphs in figure 12 and says that Luke has no reason to worry. Explain why not.

fig. 12 Growth diagrams for boys and girls.



6

Figure 10 shows the graph for the growth of a shoot. The shoot does not grow the same amount every day.

- a How can you see that in the graph?
- b Table 1 says how many millimetres the shoot grows each day.

How many millimetres does the shoot grow each day on average?

- c What is another way to calculate the mean growth per day?

Table 1

Day	Growth of the shoot
1	0 mm
2	0 mm
3	0 mm
4	0 mm
5	2 mm
6	3 mm
7	1 mm
8	5 mm
9	5 mm
10	4 mm
11	6 mm
12	7 mm

Practical activities

1

DRAWING AN APPLE

► Basics 1 | ► Learning objectives 1.O.18, 1.O.19 and 1.O.20 | ► Learning how to do research 1

 15-20 minutes

WHAT ARE YOU GOING TO DO?

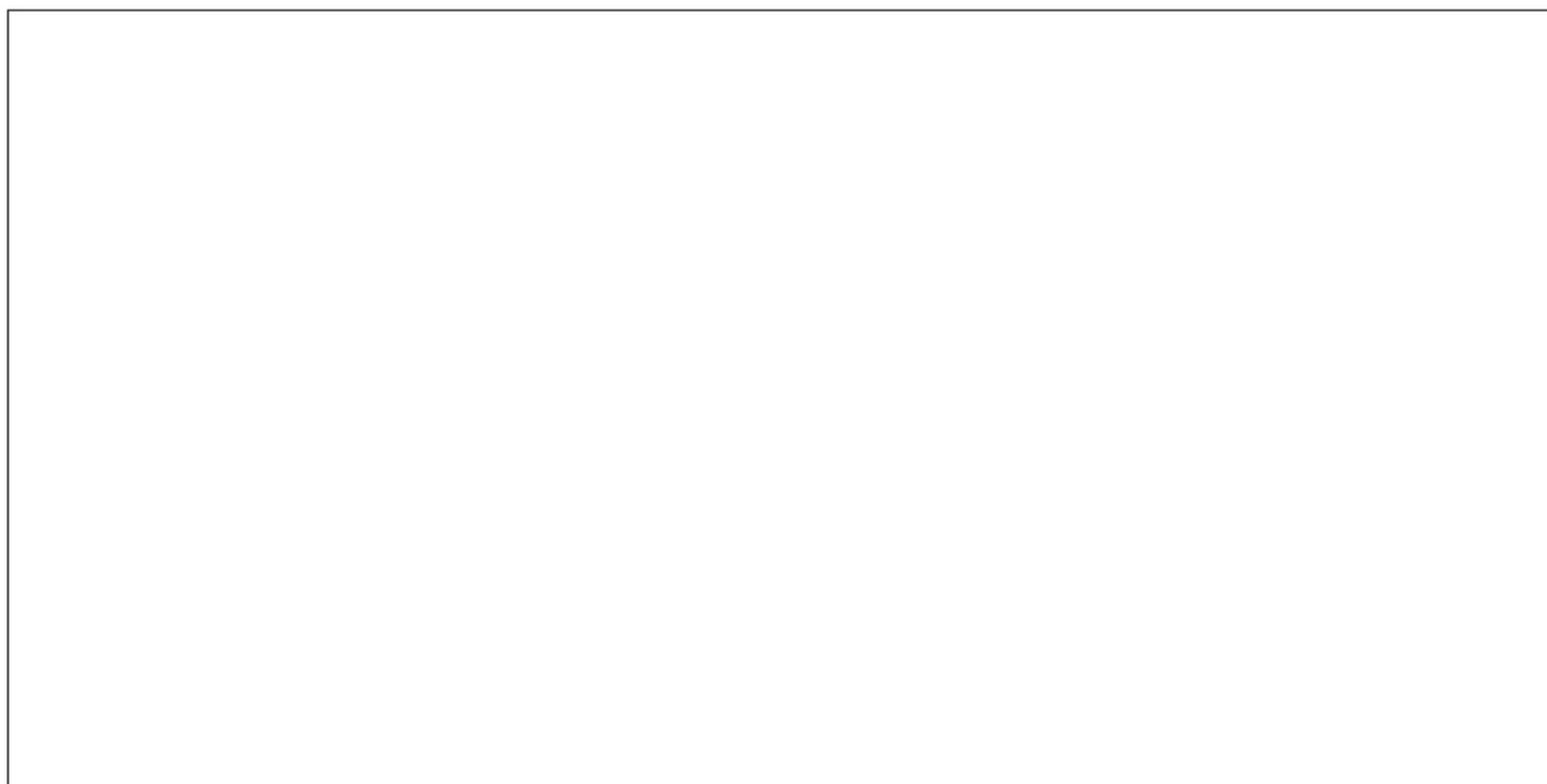
In this practical activity, you will make a true-to-life drawing and drawings of the lengthwise and transverse cross-sections of an apple.

WHAT DO YOU NEED?

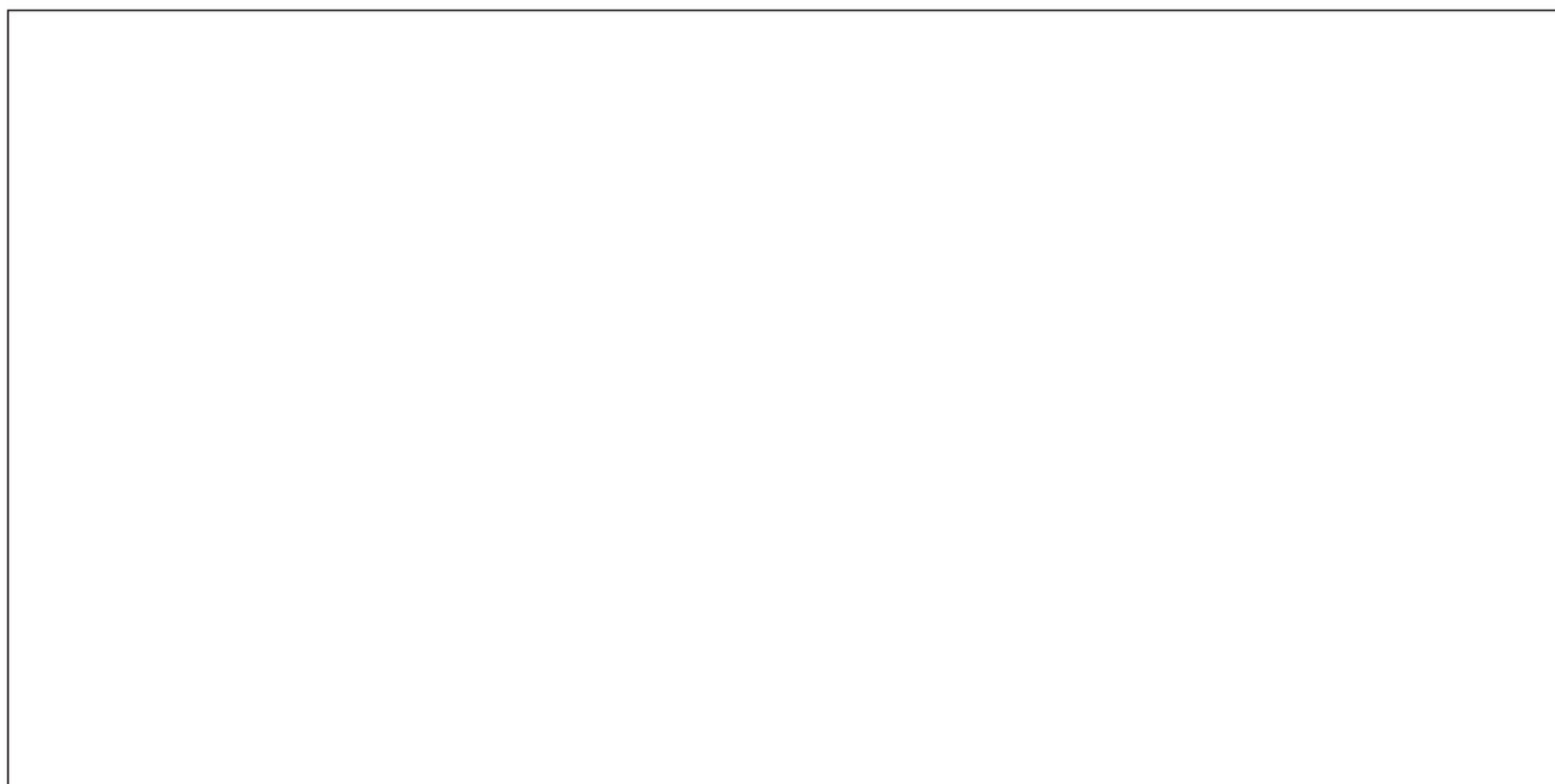
- ☐ 2 apples
- ☐ a knife
- ☐ drawing materials

WORKING METHOD

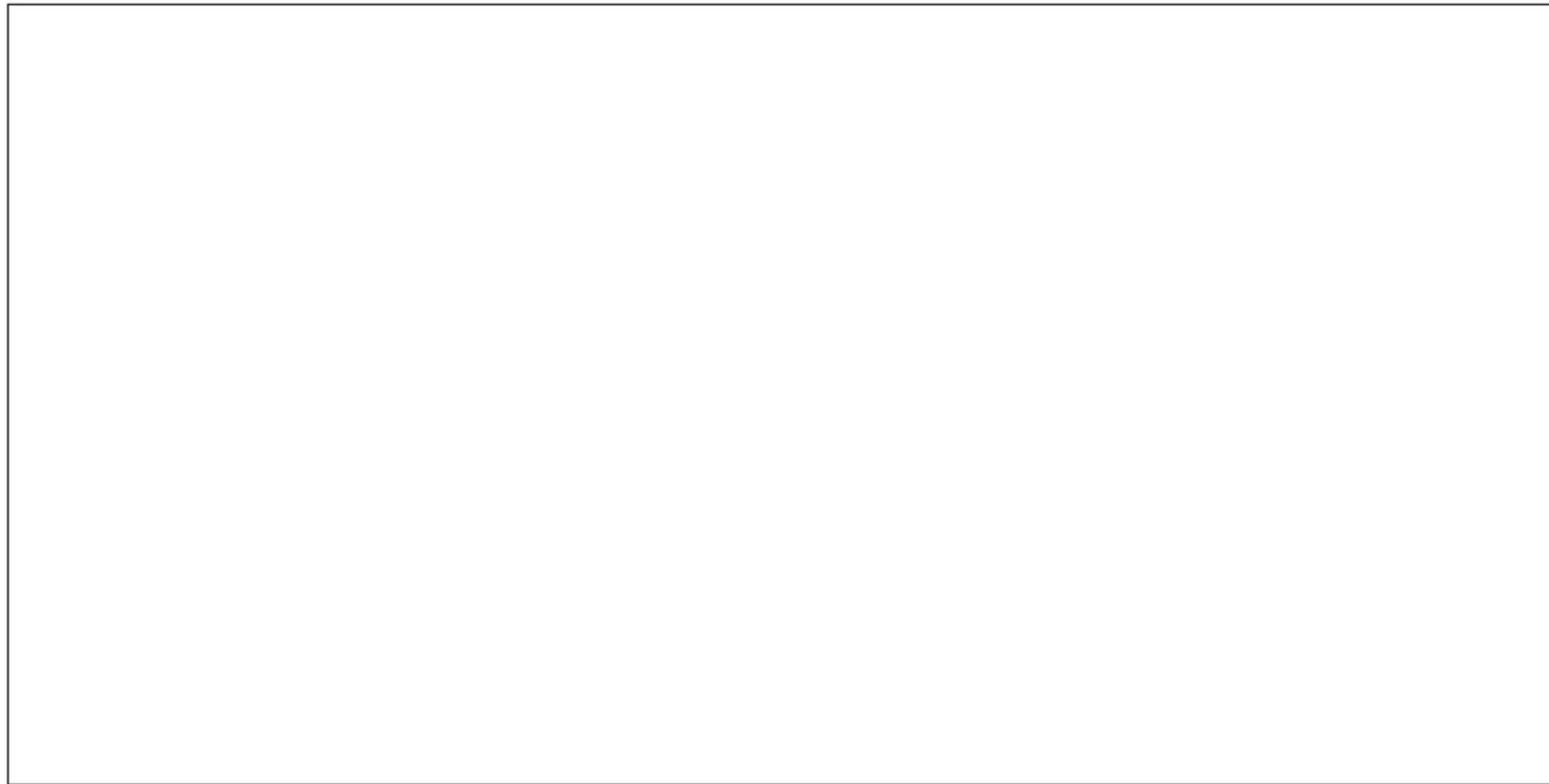
- Make a true-to-life drawing of the external view of the apple.



- Cut one of the apples in half lengthwise (downwards from the stalk).
- Make a schematic drawing of the longitudinal section of the apple.



- Cut the other apple across its middle.
- Make a schematic drawing of the transverse section of the apple. *Remember the drawing rules!*



2

A DRY SEED

► Basics 2 | ► Learning objectives 1.2.4, 1.O.18, 1.O.20 and 1.O.21 | ► Learning how to do research 1 and 2

 5-10 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will make a true-to-life drawing of the external view of a brown bean.

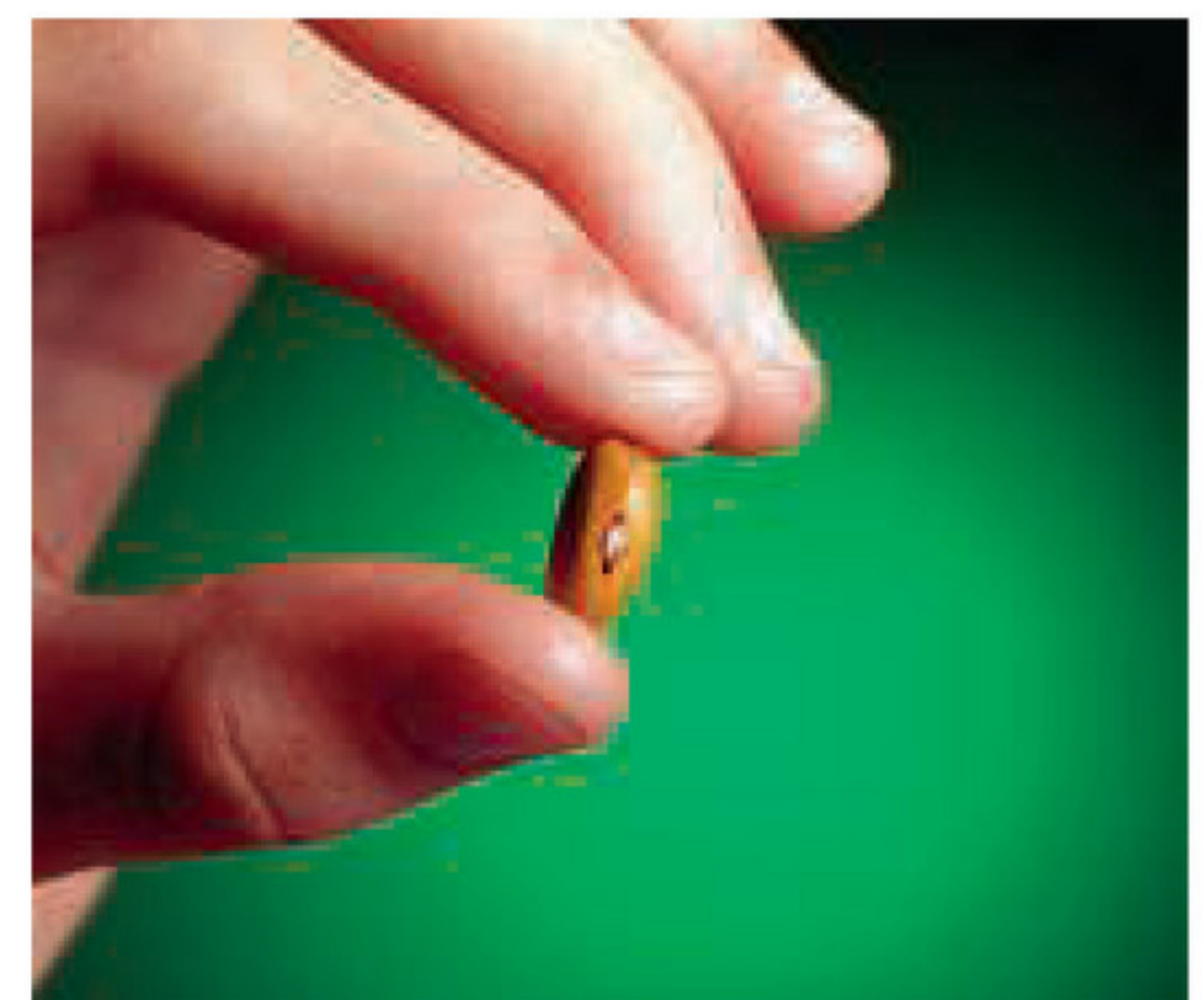
WHAT DO YOU NEED?

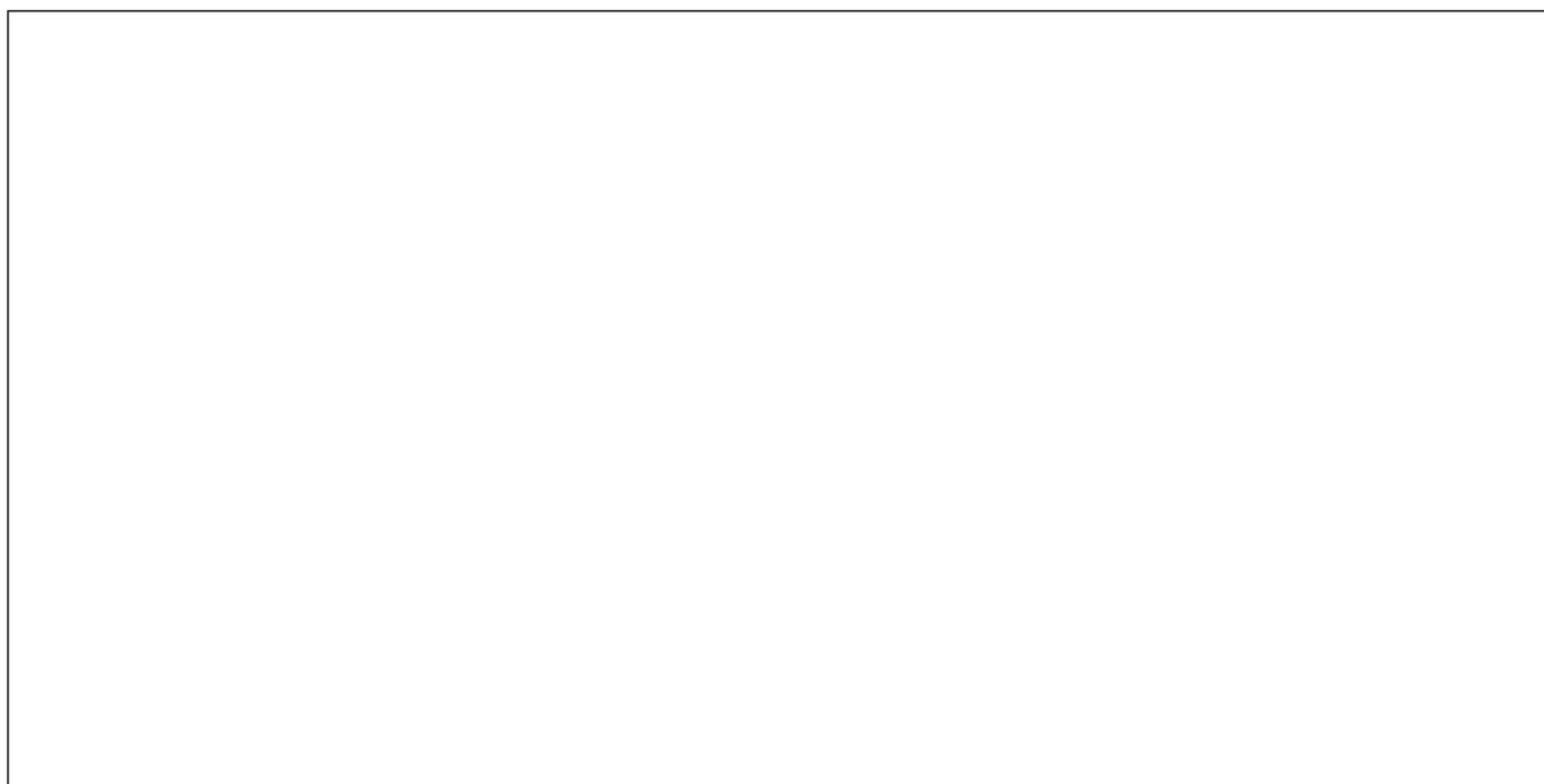
- ☐ a dry brown bean
- ☐ a magnifying glass
- ☐ drawing materials

WORKING METHOD

- Hold the bean as shown in figure 1.
- Look at the bean under the magnifying glass.
- Make a true-to-life drawing of the external view of the bean. Draw the bean about twice as big as it is in real life. Label the following parts: *heart-shaped bump – navel – poortje – zaadhuid*.

fig. 1 A brown bean.





3

A WET SEED

► Basics 2 | ► Learning objectives 1.2.4, 1.0.18, 1.0.20 and 1.0.21 | ► Learning how to do research 1 and 2

 10-15 minutes

WHAT ARE YOU GOING TO DO?

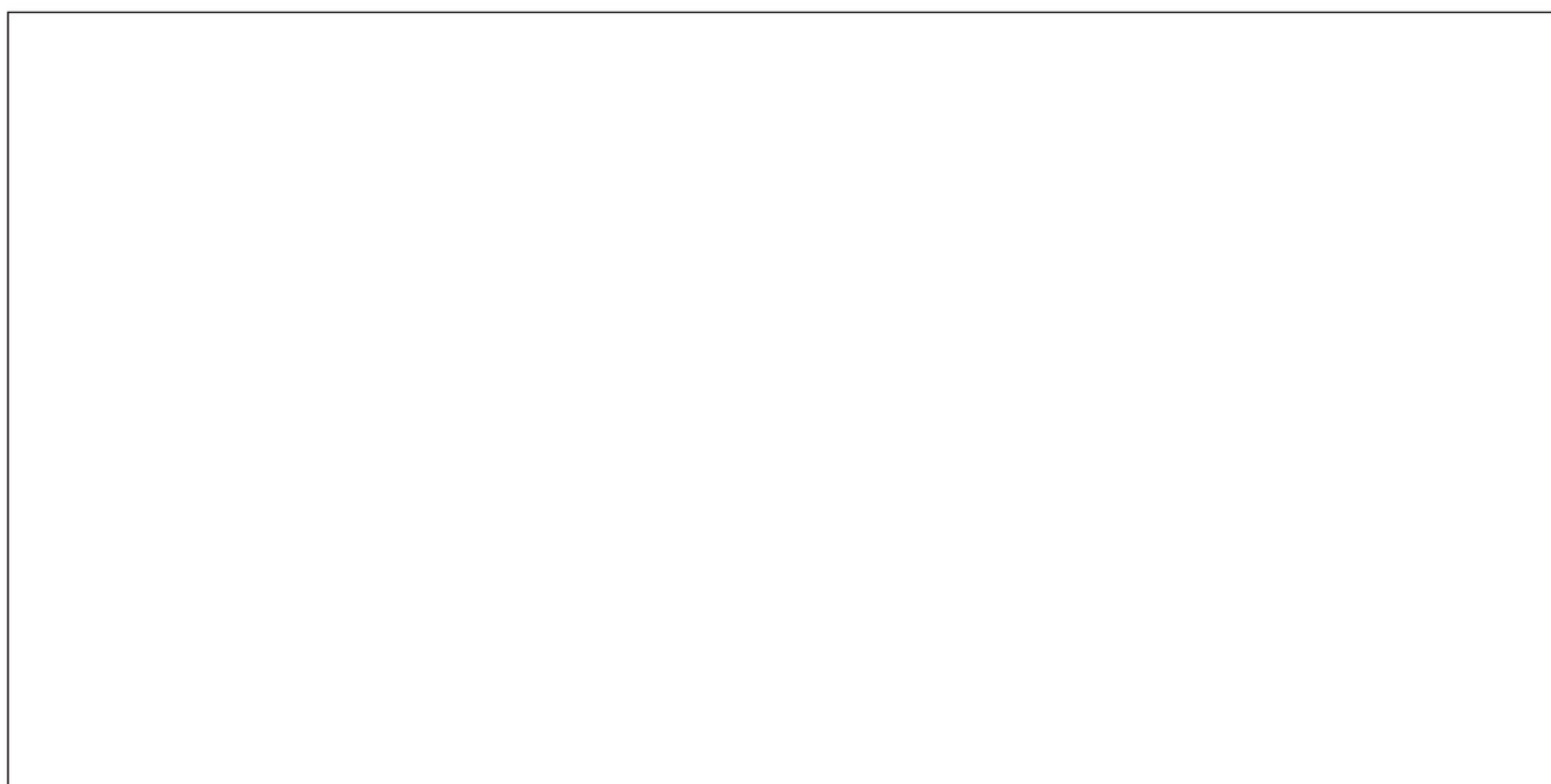
In this practical activity, you will make a true-to-life drawing of the cotyledon of a brown bean.

WHAT DO YOU NEED?

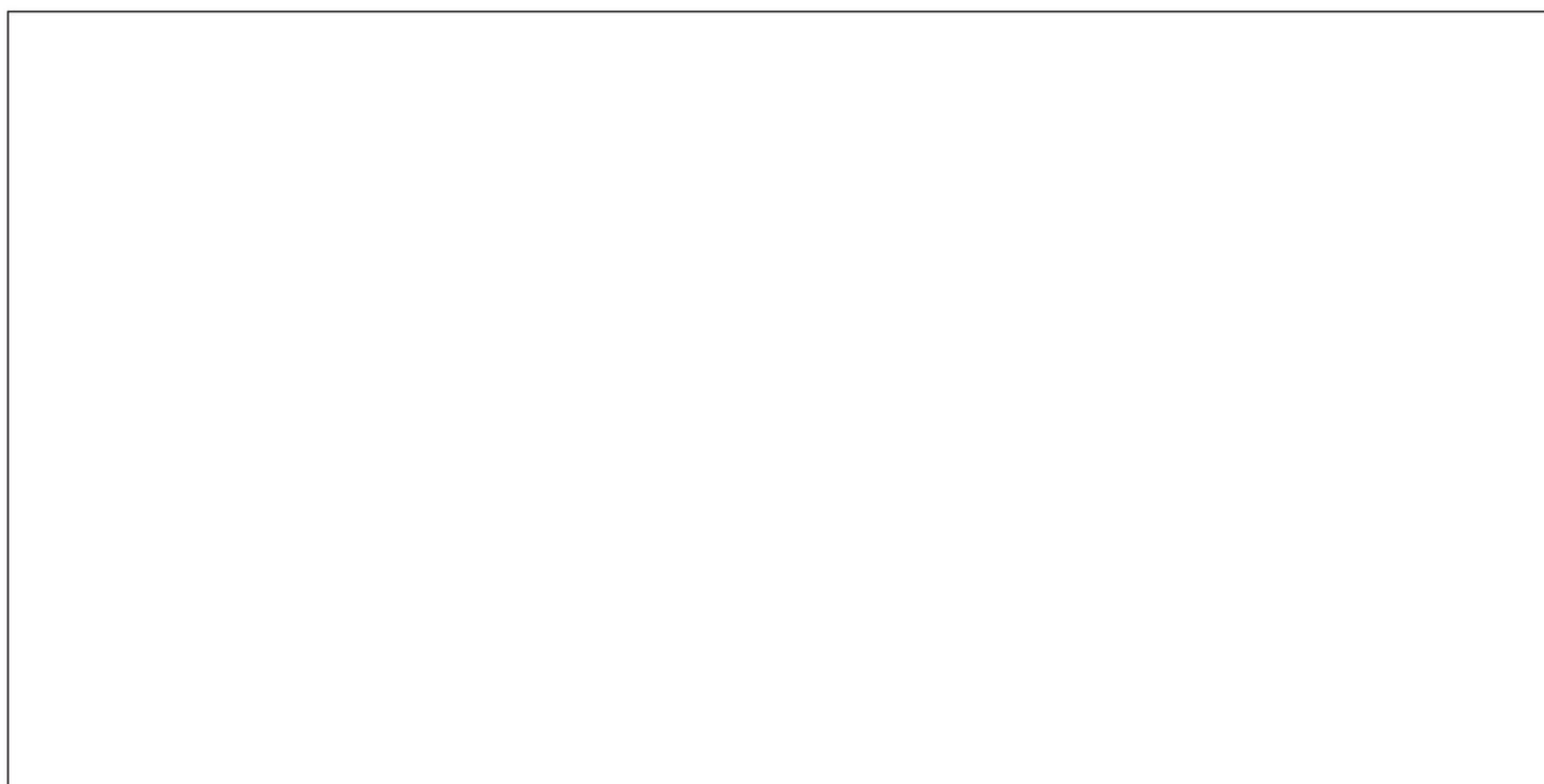
- ☐ a bean that has been soaked in water for a day
- ☐ a magnifying glass
- ☐ drawing materials

WORKING METHOD

- Carefully remove the seed coat from the bean. Start at the side opposite the hilum.
- You can see that the bean has two halves. These are called the seed leaves (cotyledons). You can also see the plant embryo's tiny root. The tip of the root is close to the opening. During germination, the root grows out through the opening.
- Make a true-to-life drawing of the brown bean without its seed coat. Label the following parts: *root – cotyledon*.



- Carefully separate the two cotyledons. One cotyledon will contain the plant embryo. The plant embryo consists of a root, stem and two small leaves. The stem is very short.
- Examine the plant embryo under the magnifying glass.
- Make a true-to-life drawing of the cotyledon with plant embryo. Label the following parts: *leaves – root – cotyledon*.



4

THE GROWTH OF A SEEDLING

► Basics 2 | ► Learning objective 1.2.4

 Lesson 1: 15-20 minutes, lessons 2 to 4: 5 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will examine the growth of a seedling over a few weeks.

WHAT DO YOU NEED?

- ☐ a glass bottle or beaker
- ☐ 5 seeds (beans or peas)
- ☐ a toilet roll
- ☐ a felt-tipped pen (and sticker, if required)

WORKING METHOD

- Write your name on the glass jar.
- Unroll enough of the toilet roll for it to fit comfortably in the glass beaker.
- Put the toilet roll in the glass.
- Place the seeds around the edge of the glass (see figure 2).
- Wet the toilet roll. It is fine if there is a small layer of water at the bottom of the beaker.

In the biology lessons that follow, you should choose a seed that is germinating well.

- In each of the next three biology lessons, measure the lengths of the root and the shoot of this seedling.
- Make a note of the measured lengths in the table.

fig. 2



	Root	Shoot
After 0 days	0 cm	0 cm
After 1 days	cm	cm
After 2 days	cm	cm
After 3 days	cm	cm

EXERCISE

1

Did your seedlings all grow at exactly the same rate? *yes / no*

5

THE EFFECT OF TEMPERATURE ON THE GERMINATION OF SEEDS

► Basics 2 | ► Learning objective 1.2.6

 Lesson 1: 10-15 minutes, lessons 2 to 4: 5 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you investigate the effect of temperature on the germination of seeds.

WHAT DO YOU NEED?

- ☐ 2 margarine tubs (or similar containers)
- ☐ moist cotton wool
- ☐ 40 cress seeds
- ☐ 2 pieces of card, 15 × 15 cm
- ☐ a refrigerator
- ☐ a thermometer

WORKING METHOD

- Put moist cotton wool in each of the tubs and then add twenty cress seeds.
- Put one tub in a warm place. Put the other tub in the refrigerator (at school or at home). It will be dark in the refrigerator, but not in the other place. This is why you should put a piece of card over each of the tubs.
- Leave the tubs to stand for three days. Make sure that the cotton wool stays wet.
- Use the thermometer to measure the temperatures of the two locations. Write this temperature down in the table.

RESULTS

- After one day, count the number of seeds that have germinated in each of the tubs.
- Write down the numbers in the table.
- Count the number of seeds that have germinated in each of the tubs after two and three days as well. Write down the numbers in the table.

Location	Temperature	Number of germinated seeds		
		After 1 day	After 2 days	After 3 days
Warm	°C			
Cold	°C			

EXERCISE

1

- a Which tub has the most germinated seeds?
in the tub in the warm place / in the tub in the refrigerator / there is no difference
- b What do you now know about the effect of temperature on the germination of cress seeds?

6

METAMORPHOSIS OF THE MEALWORM BEETLE

► Basics 3 | ► Learning objective 1.3.7

 Lesson 1: 15-20 minutes, lessons 2 to 7: 5-10 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you investigate how long the metamorphosis of the mealworm takes. You will work together with a classmate.

WHAT DO YOU NEED?

- ☐ a margarine tub with a lid
- ☐ a drill or a hot needle
- ☐ bran (oat bran)
- ☐ pieces of apple
- ☐ dry yeast from a sachet
- ☐ 10 mealworms
- ☐ a permanent marker pen or a sticker

WORKING METHOD

- Use the hot needle to drill or prick small holes in the lid of the margarine tub.
- Write your names on the margarine tub (or use a sticker).
- Put a thin layer of bran in the margarine tub until the bottom is just covered.
- Put four pieces of apple on the layer of bran.
- Add a very little bit of yeast (crumble up any yeast grains).
- Last of all, put the mealworms in the margarine tub.
- Close the lid and put the tub away.

Once a week for the next six weeks, do the following:

- Count the numbers of mealworms, shed skins (casts), pupae and mealworm beetles. Write down your observations in the table.
- Add fresh pieces of apple. You can also add a few drops of water.

	Number of mealworms	Number of casts	Number of pupae	Number of mealworm beetles
				
Week 1	10			
Week 2				
Week 3				
Week 4				
Week 5				
Week 6				

EXERCISE

1

During this exercise, you have examined an organism.

- a What is the name for the larva of this organism?
- b What is the name for the imago of this organism?
- c The number of casts may be greater than the number of pupae that appear.
Explain why.
- d Roughly how long does metamorphosis take in a mealworm?

7

THE HEIGHTS OF YOUR CLASSMATES

► Basics 4 | ► Learning objectives 1.O.24 | ► Learning how to do research 3

 20-25 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you calculate the average heights of your classmates.

WHAT DO YOU NEED?

- ☐ a measuring tape or ruler (going up to 2 m in length)

WORKING METHOD

- Take your shoes off. Ask the person next to you to measure how tall you are. Write down your height in the table below.
- Write down your height on the blackboard. Your teacher will tell you how. Data for the boys and the girls should be noted down separately.
- Calculate the average heights of:
 - a all the boys in your class
 - b all the girls in your class
 - c all the boys and girls together
- Complete the table.

fig. 3 Measuring your height.



	Height
Me	
The average of all boys in the class	
The average of all girls in the class	
The average of all pupils in the class	

8

THE EFFECT OF CARBON DIOXIDE ON PHOTOSYNTHESIS

► Basics 5 | ► Learning objectives 1.5.11 and 1.5.12

 25-35 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you are going to investigate the effect of carbon dioxide on the rate of photosynthesis by a water plant. You will use carbonated (fizzy) water, which has carbon dioxide dissolved in it.

WHAT DO YOU NEED?

- ☐ 2 test tubes
- ☐ 2 pieces of a water plant (for example waterweed)
- ☐ a stopwatch
- ☐ a sharp blade
- ☐ tap water that has been boiled and then allowed to cool again
- ☐ carbonated mineral water (fizzy)

WORKING METHOD

- Number the test tubes and fill test tube 1 with boiled and cooled tap water and test tube 2 with carbonated mineral water.
- Make sure the pieces are equally long. You can lay them next to each other and use the knife to cut them to the same size.
- Put a freshly cut stalk of water plant into each test tube with the stalk upwards (see figure 4).
- Put the plants in a well-lit place and count the number of bubbles that each plant produces in five minutes. Make a note of the results of your measurements in the table.

fig. 4



	In boiled tap water	In carbonated mineral water
Number of bubbles in five minutes		
Number of bubbles per minute		

EXERCISE

1

- a In which test tube did you see more bubbles: in the test tube with boiled and cooled tap water, or the tube with carbonated mineral water?
- b What gas is in these bubbles?
- c In which test tube does photosynthesis go faster: the test tube with boiled and cooled tap water, or the one with carbonated mineral water? Explain your answer.

9

GROWING SPROUTS AND SHOOTS

► Basics 5 | ► Learning objectives 1.5.13, 1.0.18 and 1.0.20 | ► Learning how to do research 1

 Lesson 1: 15-20 minutes, lesson 2: 10-15 minutes

WHAT ARE YOU GOING TO DO?

Sprouts or shoots are seedlings that you can eat. Familiar ones are cress, alfalfa and beansprouts. Red cabbage, rocket, sunflowers and pumpkins are others that can be eaten as sprouts. Because sprouts and shoots are nothing more than seedlings, they can be grown quickly and easily.

In this practical activity, you are going to grow a few seedlings and make drawings of a seedling.

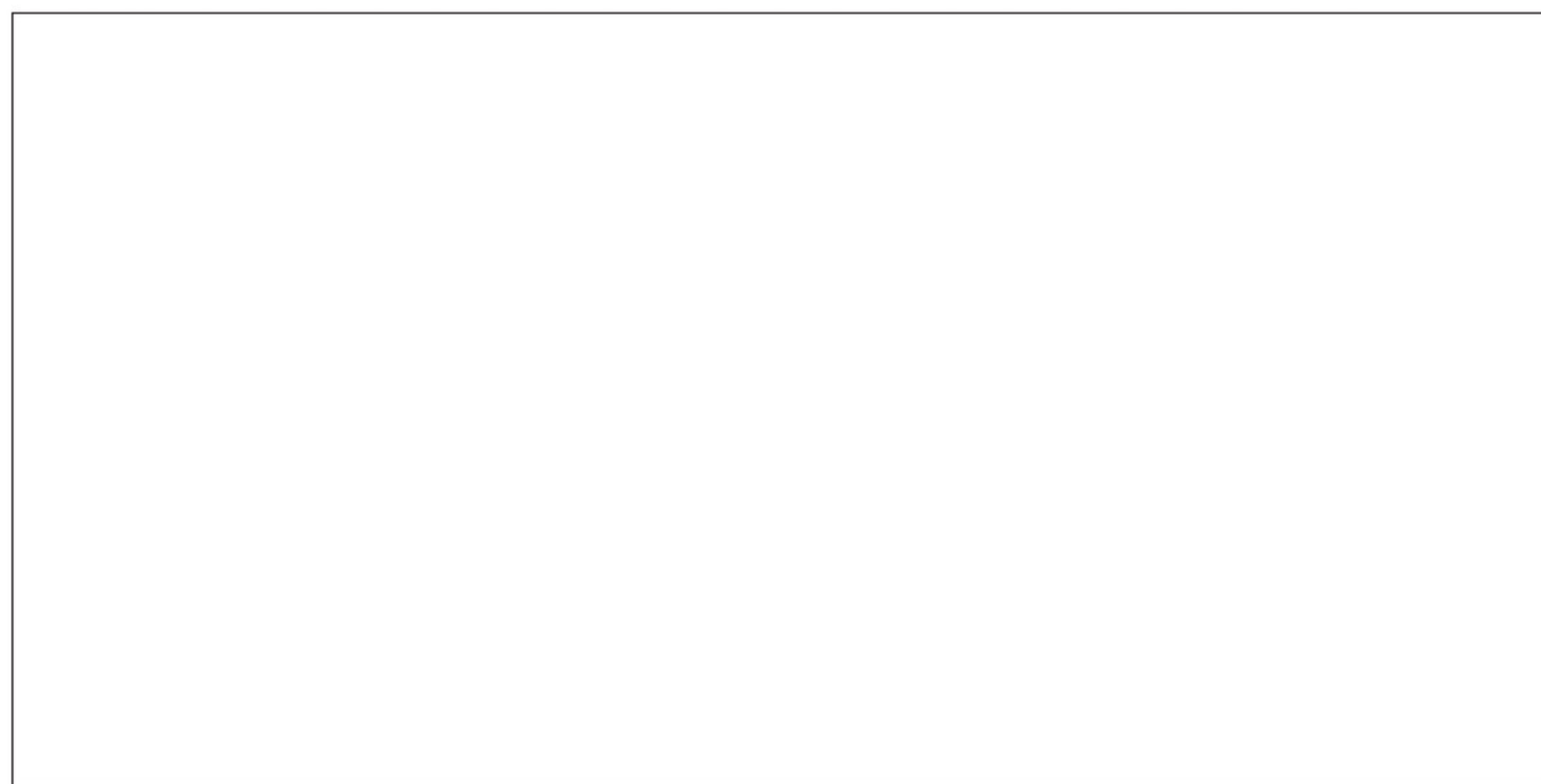
fig. 5 A growing kit (glass bowl).

**WHAT DO YOU NEED?**

- ☐ a packet of seeds of a sprouting vegetable
- ☐ a growing kit (see figure 5): a Petri dish with cotton wool or a plastic tub with cotton wool
- ☐ drawing materials

WORKING METHOD

- Scatter the seeds in a thin layer on the sowing grid or on the cotton wool.
- Fill the tub with water and place it in the light at room temperature (20 °C).
- Top up the water as necessary (daily). Most sprouts and shoots will have germinated after approximately a week.
- Make a true-to-life drawing of a seedling. Label the following parts: *stem – root – root hairs – seed leaves*.



- You can now cut off and eat the sprouts. You can generally keep sprouts and shoots in the refrigerator for a week without loss of quality.

Summary

BASICS 1

ORGANISMS

1 You can explain what an organism is.

- An organism is living creature.
 - Living creatures have life processes.

2 You can list the seven life processes.

- Life processes that are about the uptake and emission of substances:
 - breathing
 - feeding
 - excreting
- Life processes that are about responding to the surroundings:
 - sensing (sight, hearing, touch, smell, taste)
 - moving
- Life processes that are about survival:
 - reproducing
 - growing

3 You can distinguish between things that are living, dead and non-living (never alive).

- Something is alive if it has life processes.
- Something is dead if it no longer has life processes.
 - Something dead was once alive.
- Something is non-living if it was never alive at all.

BASICS 2

GROWTH AND DEVELOPMENT

4 You can describe what growth and development are.

- Growth is when an organism gets larger and heavier.
- Development: the structure of an organism changes.
 - Development lets parts of the organism work better.
 - New parts may appear.

5 You can list parts of a seed and their functions.

- Seed coat: protects the seed.
- Hilum: this is where the seed was attached to the fruit.
- Micropyle: the seed absorbs water through the pore.
- Plant embryo: the start of a new plant.
- Seed leaves: food reserve is stored here.

6 You can describe the lifecycle of a seed plant.

- Germination: a seed absorbs water and the seed coat then breaks open.
- The root grows and comes out of the seed.
- The seed leaves appear above the ground and form the first leaves.
- The seedling is the small plant that is produced on germination.
- Flowers grow on the mature plant.
- Fruits containing seeds are produced from the flowers.

BASICS 3

METAMORPHOSIS

7 You can describe what metamorphosis is.

- Metamorphosis:
 - The body structure of an animal and the way it lives change when it grows into an adult.
 - The immature animal (before metamorphosis) is called a larva.

8 You can describe the lifecycles of cabbage white and of a frog.

- The lifecycle of a cabbage white:
 - four stages: egg → caterpillar → pupa → imago
 - caterpillar (larva): eats a lot, grows quickly just after shedding its skin
 - pupa: the animal is inside a cocoon, does not eat and usually does not move
 - metamorphosis: wings, large eyes, proboscis, antennae
 - imago: adult butterfly
- The lifecycle of a frog:
 - three stages: egg → tadpole → frog
 - egg: frogspawn, a clump of frogs' eggs in a pond
 - tadpole: breathes with gills and through the skin, eats algae
 - metamorphosis: tail and gills disappear, legs and lungs appear
 - frog: lives in water and on land, breathes with its lungs and through the skin

BASICS 4

HUMANS**9 You can describe various types of development in humans.**

- Physical development: changes in the body.
- Mental development: changing intelligence, emotions and personality.
- Motor development: learning to move.

10 You can list the stages of life in humans with the ages and characteristics.

- Growth spurt: a period of rapid growth.
- Each stage of life does not last equally long in all people.
 - The ages stated for each stage are only average.
- Baby, age 0 to 1.
 - growth spurt
 - is dependent on other people
- Toddler, age 1 to 3.
 - learns e.g. to talk and walk
- Pre-school: age 3 to 5.
 - learns e.g. to ride a bike, draw and play together
- (Junior) schoolchild: age 5 to 12.
 - mental development, e.g. reading, writing and arithmetic
- Teenager, age 12 to 16+.
 - growth spurt
 - rapid physical and mental development
 - reproductive organs start to function
 - emotions change, moods can swing a great deal
- Young adult, age 16+ to 21.
 - Young adults become fully independent.
- Adult, age 21 to 65.
- Older person (elderly): over 65.
 - Many elderly people need assistance.

BASICS 5

MAKING FOOD

11 You can explain that photosynthesis makes food for animals and people.

- Plants use photosynthesis to produce the energy-rich substance glucose.
 - A plant uses glucose to make all sorts of other high-energy substances.
 - This lets the plant grow and develop.
 - Humans and animals eat plants as food (to get the substances and the energy).
- A plant makes oxygen by photosynthesis.
 - Humans and animals need oxygen

12 You can describe photosynthesis.

- Photosynthesis: a plant makes glucose using energy from sunlight.
 - The plant uses water from the soil and carbon dioxide from the air.
 - The plant uses energy from sunlight.
 - Glucose and oxygen are produced during photosynthesis.
 - Oxygen is released to the atmosphere.
- Photosynthesis takes place in all the green parts of a plant.
 - mostly in the leaves

13 You can state which parts of plants are used as food by humans.

- Parts of plants that people use as food:
 - fruits (e.g. apple, tomato)
 - seeds (e.g. grains, rice)
 - roots (e.g. beetroot, carrot)
 - stems (e.g. asparagus, celery)
 - leaves (e.g. lettuce, spinach)

BASICS 6

ALL DIFFERENT

14 You can describe adaptations in plants.

- Organisms have adaptations to their way of life and their living environment.
- Adaptations in water plants.
 - The stems are weak.
 - The stems can contain air channels (e.g. in water lilies).
- Adaptations in terrestrial (land) plants:
 - in damp environments: large, thin leaves, few roots or small roots
 - in a dry environment: small, thick leaves, a lot of roots or large roots
- Adaptations for defence:
 - thorns (e.g. brambles)
 - stinging hairs (e.g. stinging nettle)
 - toxins (e.g. coffee plant)

15 You can describe adaptations in animals.

- Adaptations in water animals:
 - In fish the scales are covered in a layer of slime.
 - The body is streamlined.
- Adaptations in birds' beaks:
 - cone-shaped beak: for seeds
 - tweezer-like beak: for insects
 - hooked beak: for prey animals
 - long, pointed beak: for animals in the soil
 - flattened beak: for plankton
- Adaptations in an animal's mouth:
 - anteater: long, sticky tongue for catching insects, no teeth
 - squirrel (rodent): four sharp, strong teeth

- Animals' adaptation to the ground conditions:
 - plantigrades: walk on the entire sole of the foot (e.g. bear)
 - digitigrades: walk on the toes (e.g. cat)
 - unguligrades (hoofed animals): walk on the tips of the toes (e.g. horse)
- Adaptations for defence:
 - spines (e.g. hedgehog)
 - camouflage (e.g. leaf-tail gecko)
 - appearing dangerous (e.g. sable grasshopper)
 - shell or armour (e.g. tortoise)
 - toxins (e.g. scorpion)

EXTRA 7

THE IMPORTANCE OF PHOTOSYNTHESIS (IN DEPTH)

16 You can explain that many fuels and raw materials exist because of photosynthesis.

- Fossil fuels: petroleum, natural gas, coal.
 - Formed millions of years ago from the remains of organisms.
- Raw materials:
 - from petroleum: plastics and other raw materials
 - from plants: e.g. cotton, wood
 - from animals: e.g. wool, linen, bonemeal

EXTRA 8

YOUNG THAT STAY AND YOUNG THAT GO (EXTENSION)

17 You can list the characteristics of altricial and precocial animals.

- Altricial animals are often naked, helpless and blind shortly after being born.
 - They stay in a nest for a few weeks, looked after by their parents.
 - By the time they leave the nest, birds can fly and mammals can run.
- Precocial animals have feathers or fur and can see as soon as they are born.
 - They can follow their parents independently within a few hours of being born.
 - Birds may only be able to fly after several months.
- Precocial animals are further developed when they are born than altricial animals, but they develop more slowly than altricial animals.

RESEARCH

LEARNING HOW TO DO RESEARCH & PRACTICAL ACTIVITIES

18 You know the difference between a true-to-life drawing and a schematic one.

19 You know the difference between an external view, a longitudinal section and a transverse section.

20 You can make drawings according to the drawing rules.

21 You can use a magnifying glass.

22 You can show results in a table and a graph.

23 You can describe what a table or graph is telling you.

24 You can calculate averages (means).

 Go to the *Flash cards* and the *Diagnostic test*.

2

Organs and cells

Living organisms consist of parts such as cells, tissues and organs. Each part has its own structure and function. Together, the parts keep the organism alive.

BASICS

1	The organs of animals	86
2	The organs of plants	94
3	Tissues	103
4	Cells	110
5	The cell nucleus	116
6	Cell division	122
	How it fits together	128
	<i>Baobab trees are dying</i>	

EXTRA

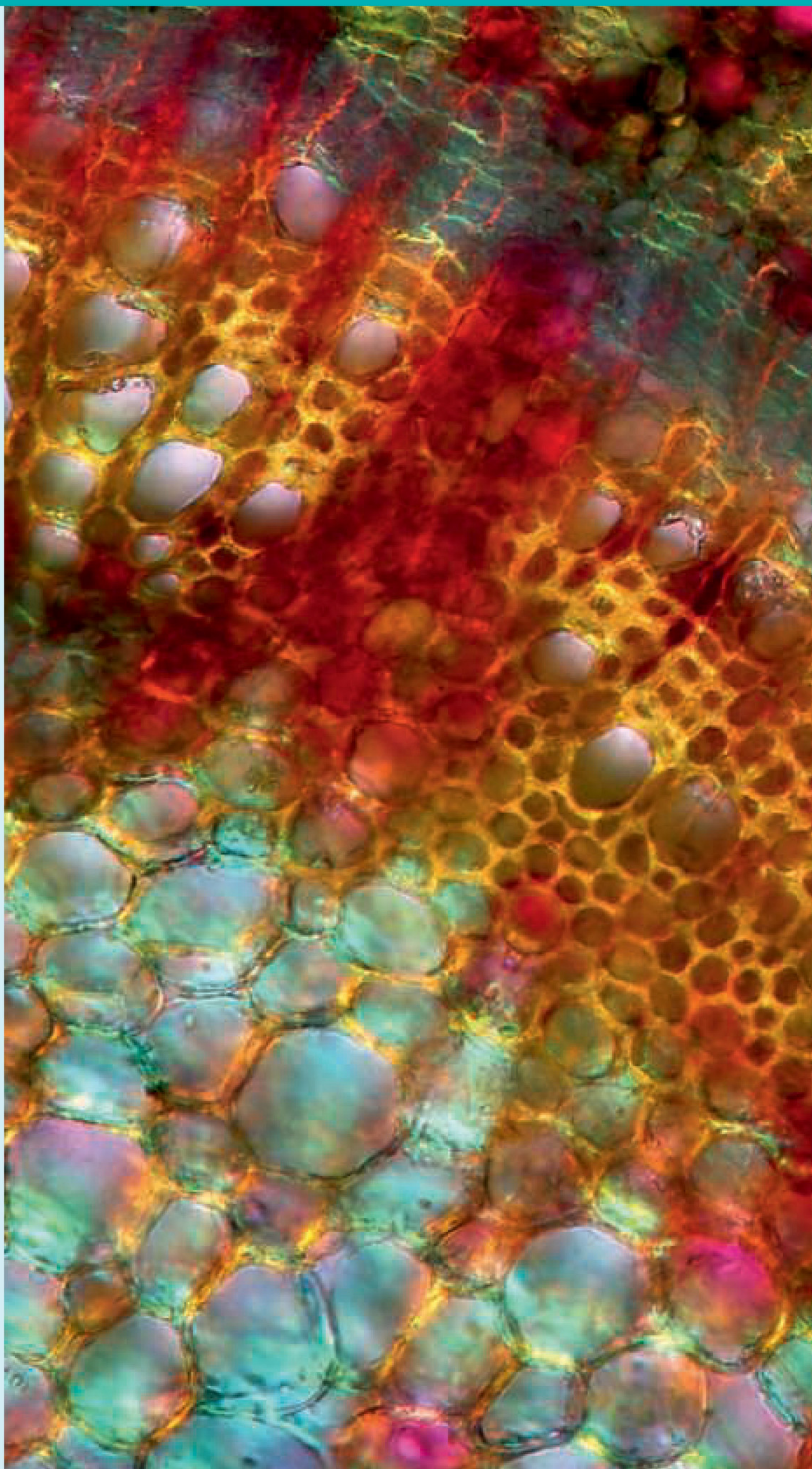
7	Single-celled organisms	130
8	DNA testing	133

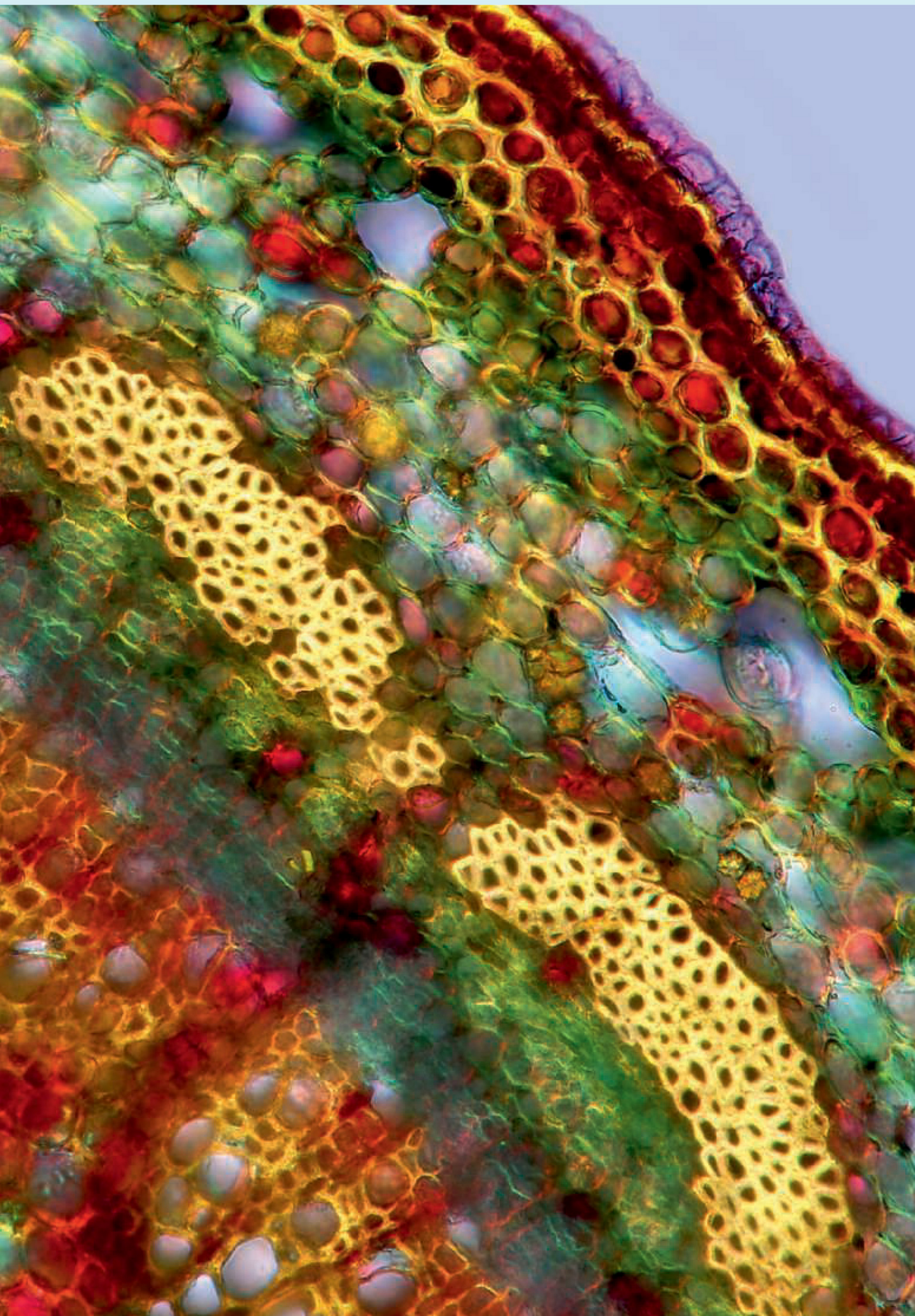
RESEARCH

	Learning how to do research	137
	Practical activities	145

TO FINISH

	Summary	159
	Diagnostic test	





1 The organs of animals

LEARNING OBJECTIVES

2.1.1 You can identify the organs in a torso and in a cross-section of the body.

- ▶ Learning how to do research 1 and 2
- ▶ Practical activities 1, 2, 3 and 4

2.1.2 You can identify the organs in the organ systems of humans and animals.

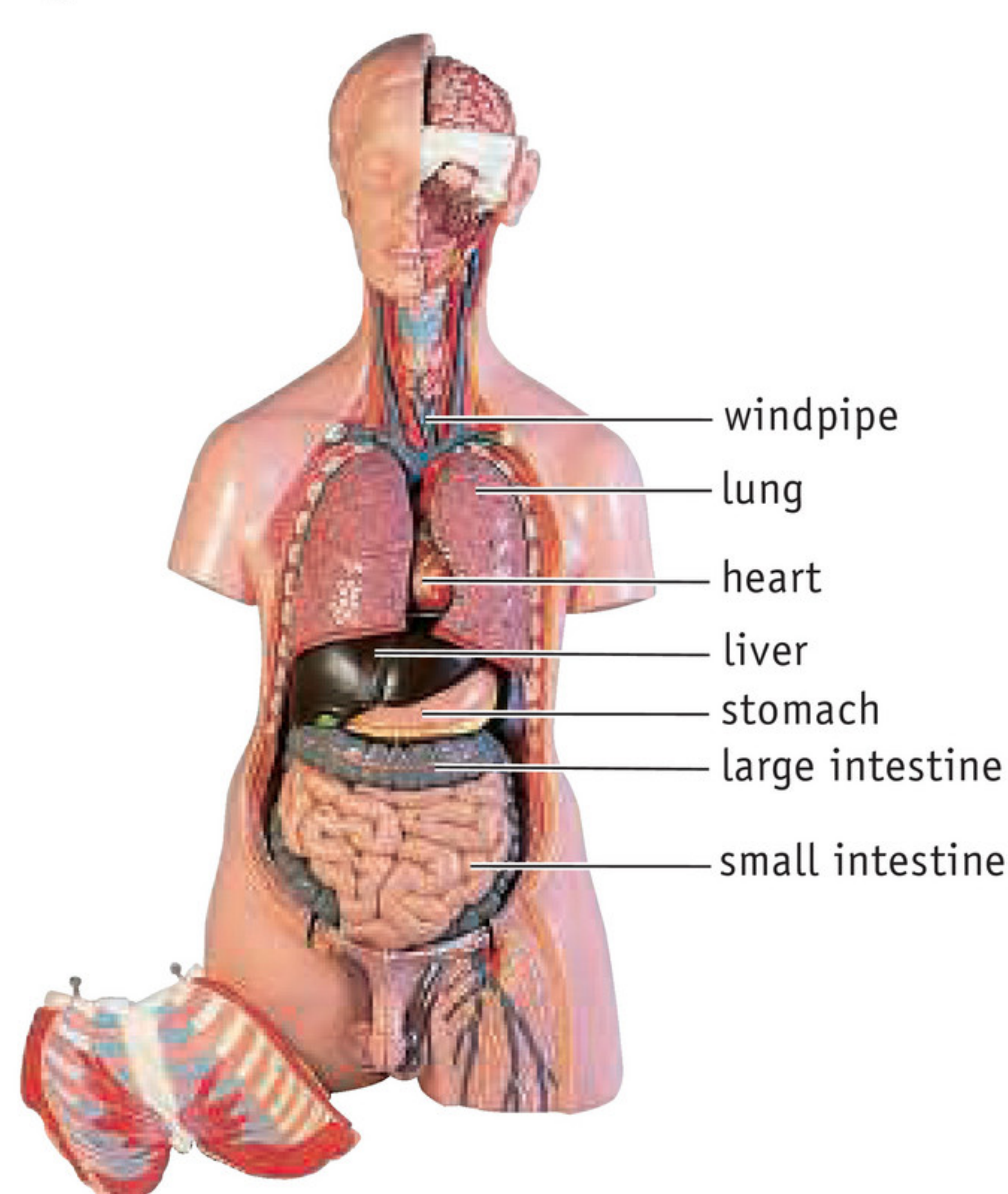
TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	2.1.1	2.1.2
Remembering	2a	2c
Understanding	1, 2b, 4	3, 4
Using	5ad, 7ab	5c
Analysing	5b, 7c	6, 7c

The organs in your body perform various functions such as transporting substances or breathing. Organs work together in organ systems.

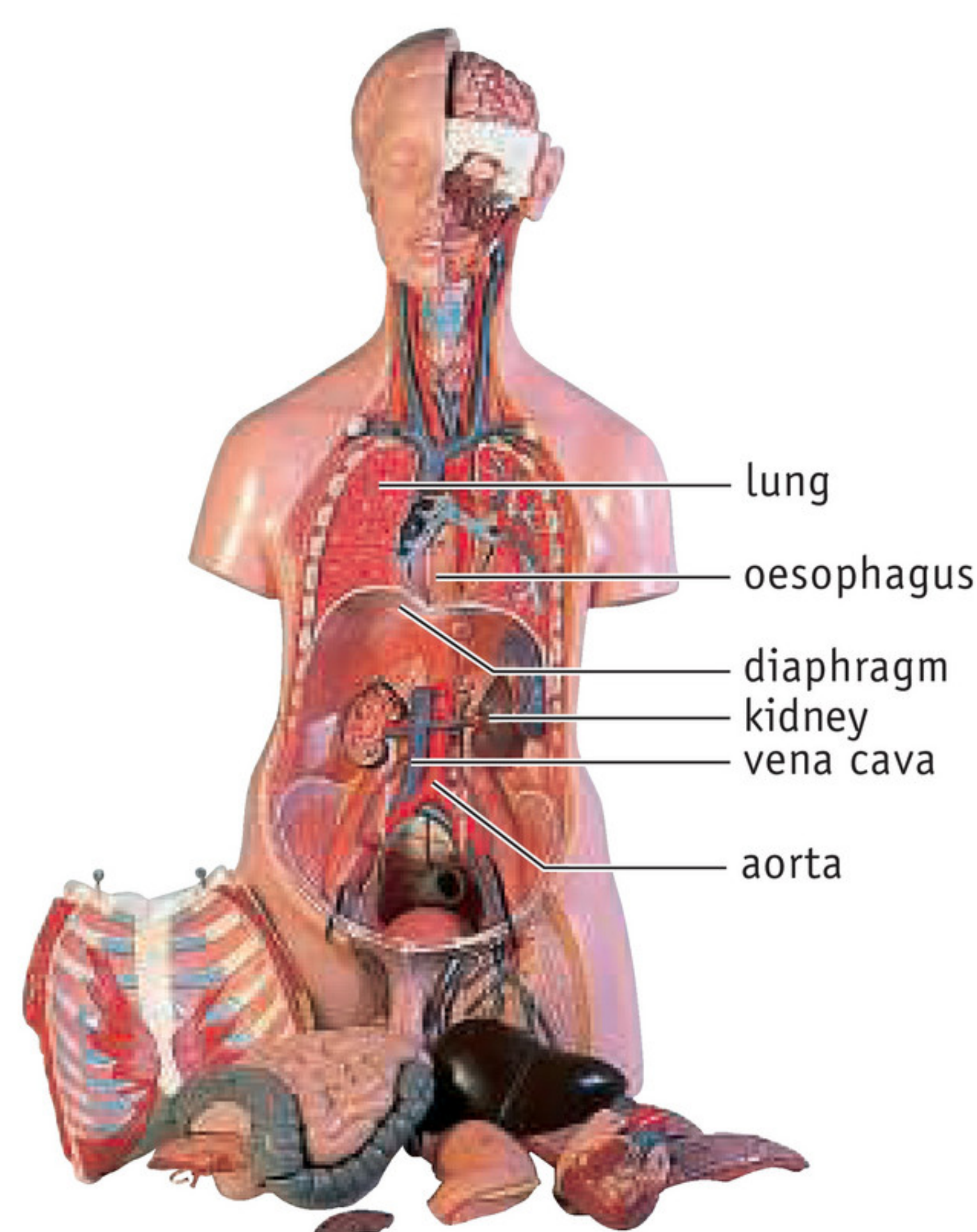
THE ORGANS OF HUMANS

An **organ** is a part of an organism that performs a specific function. The skin, for example, protects the body and the heart pumps blood through the blood vessels. Figure 1 shows a model of the torso and head of a man. A model like this is called a torso. You can see the positions of various organs in the body and what they look like.

fig. 1 Torso.



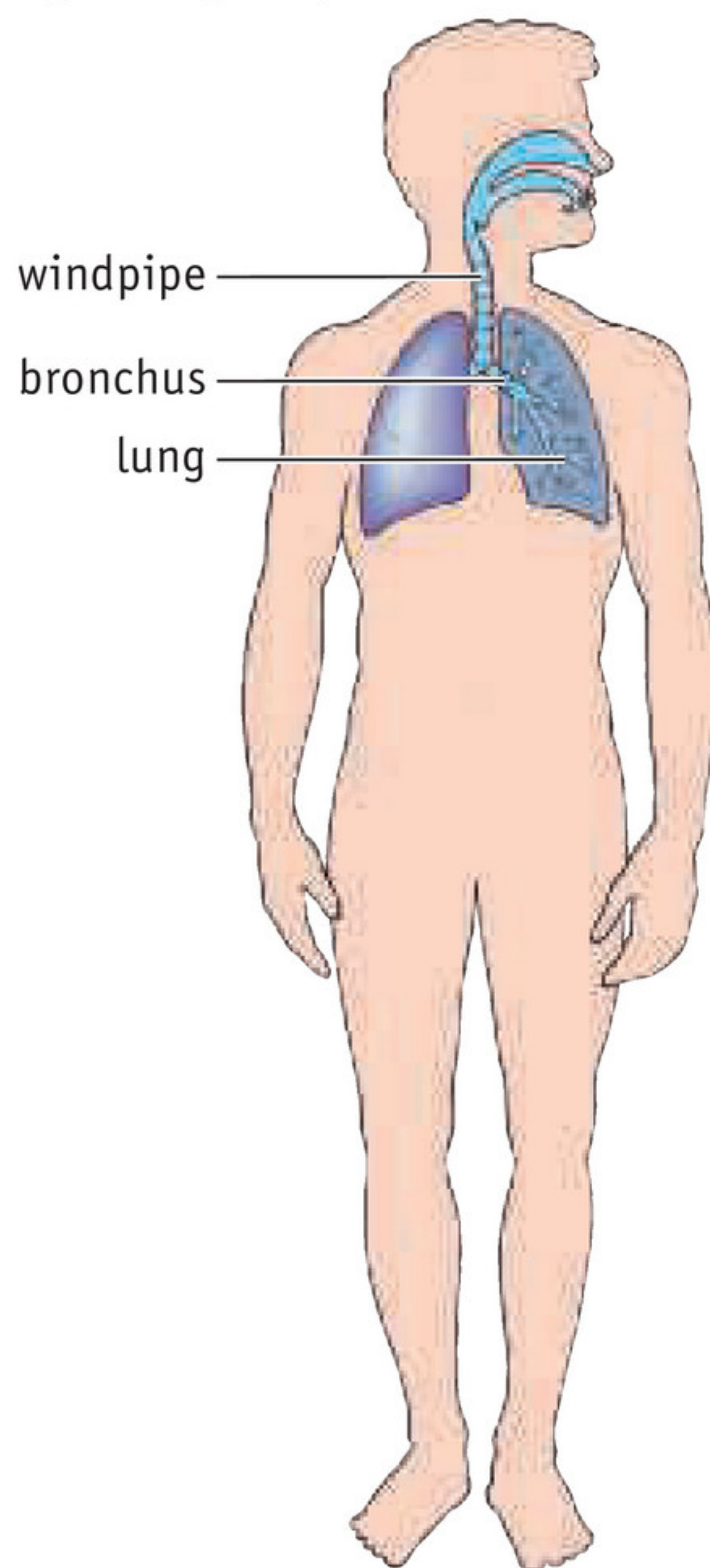
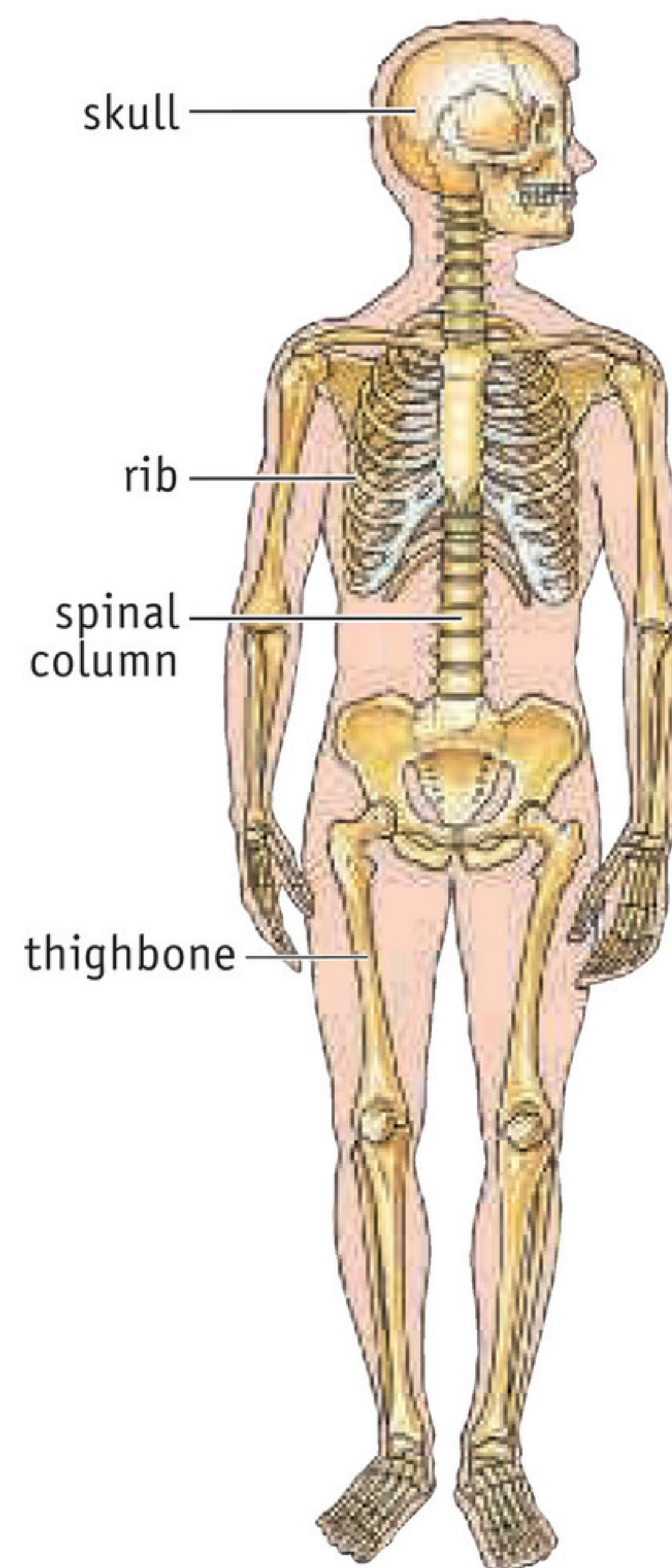
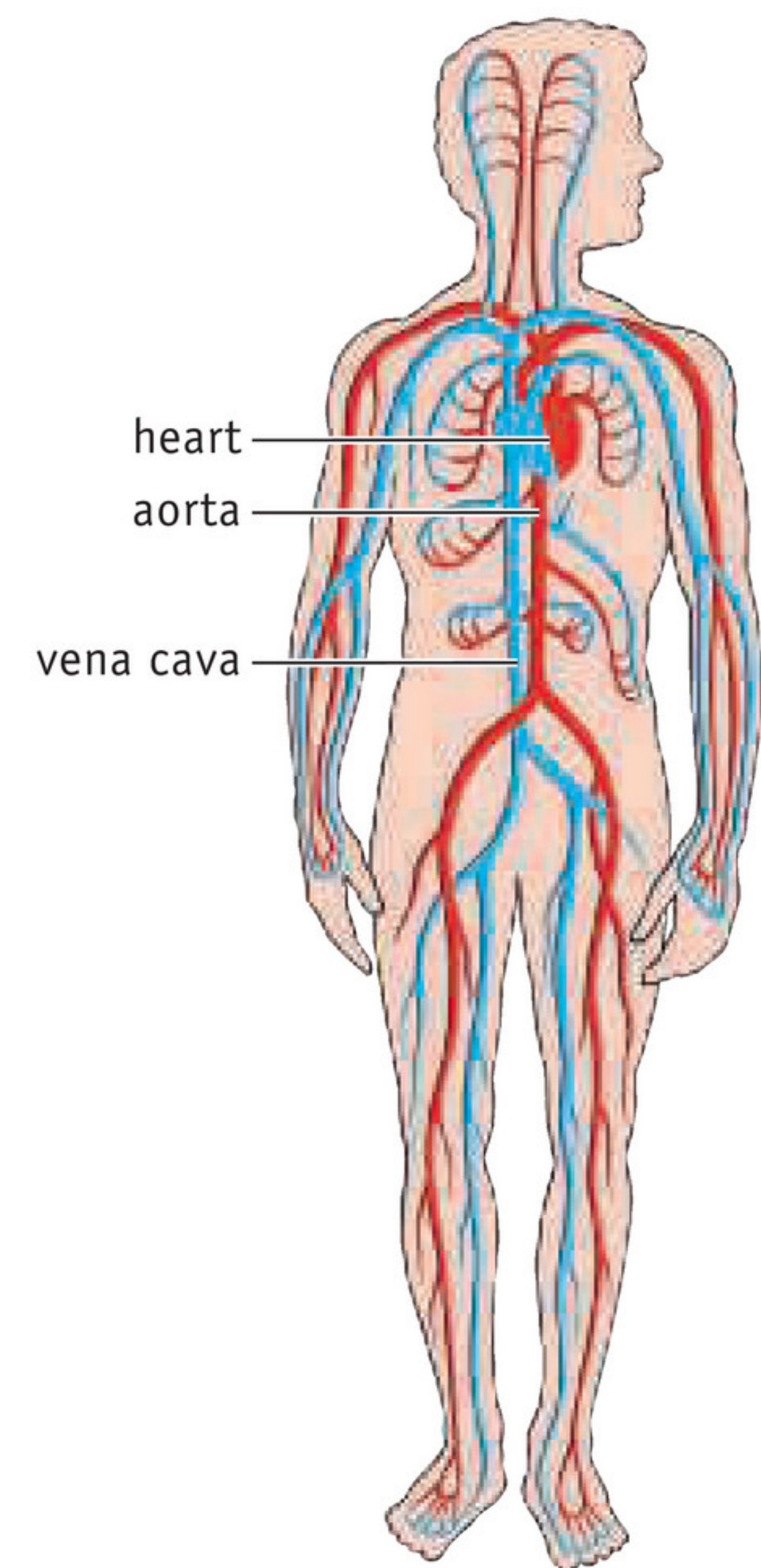
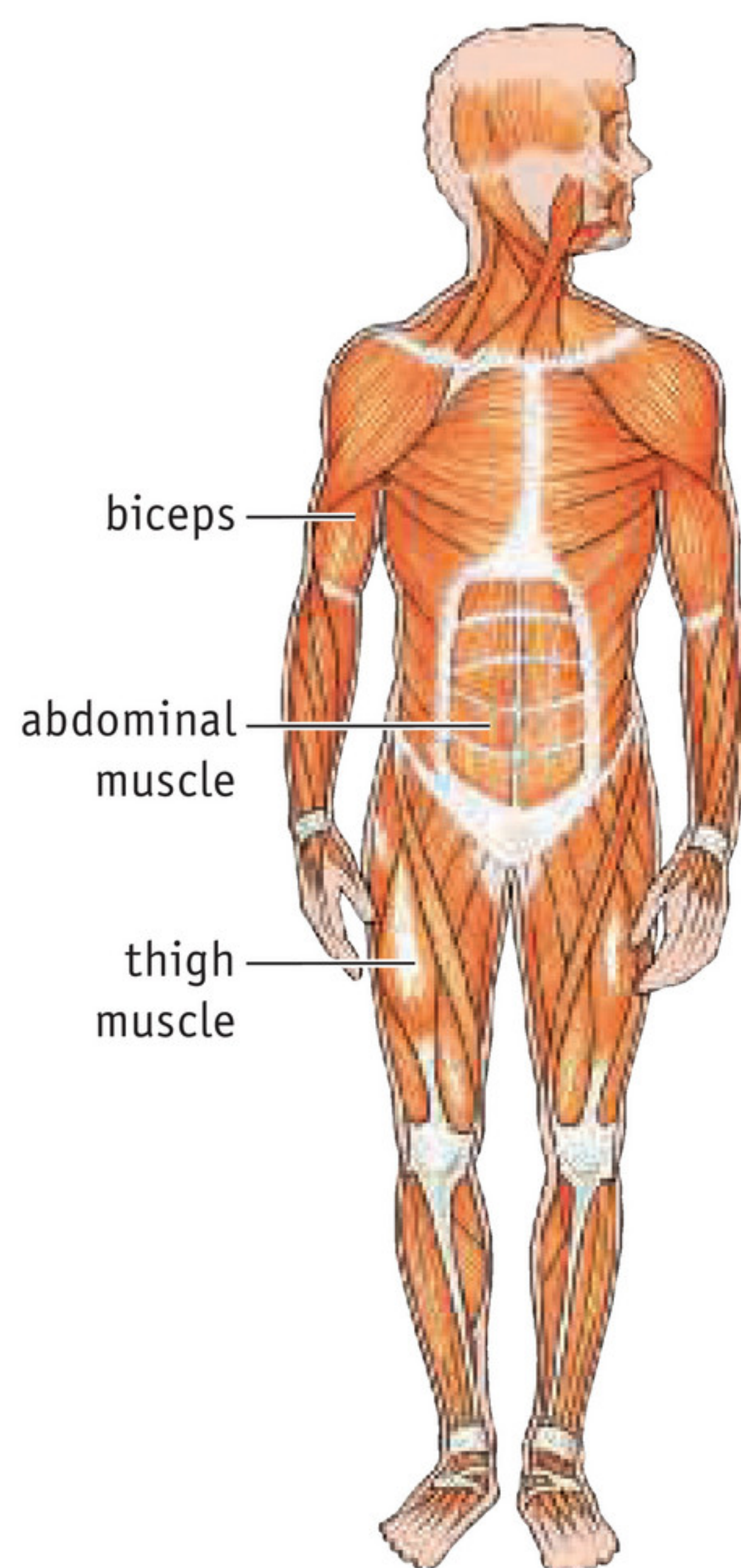
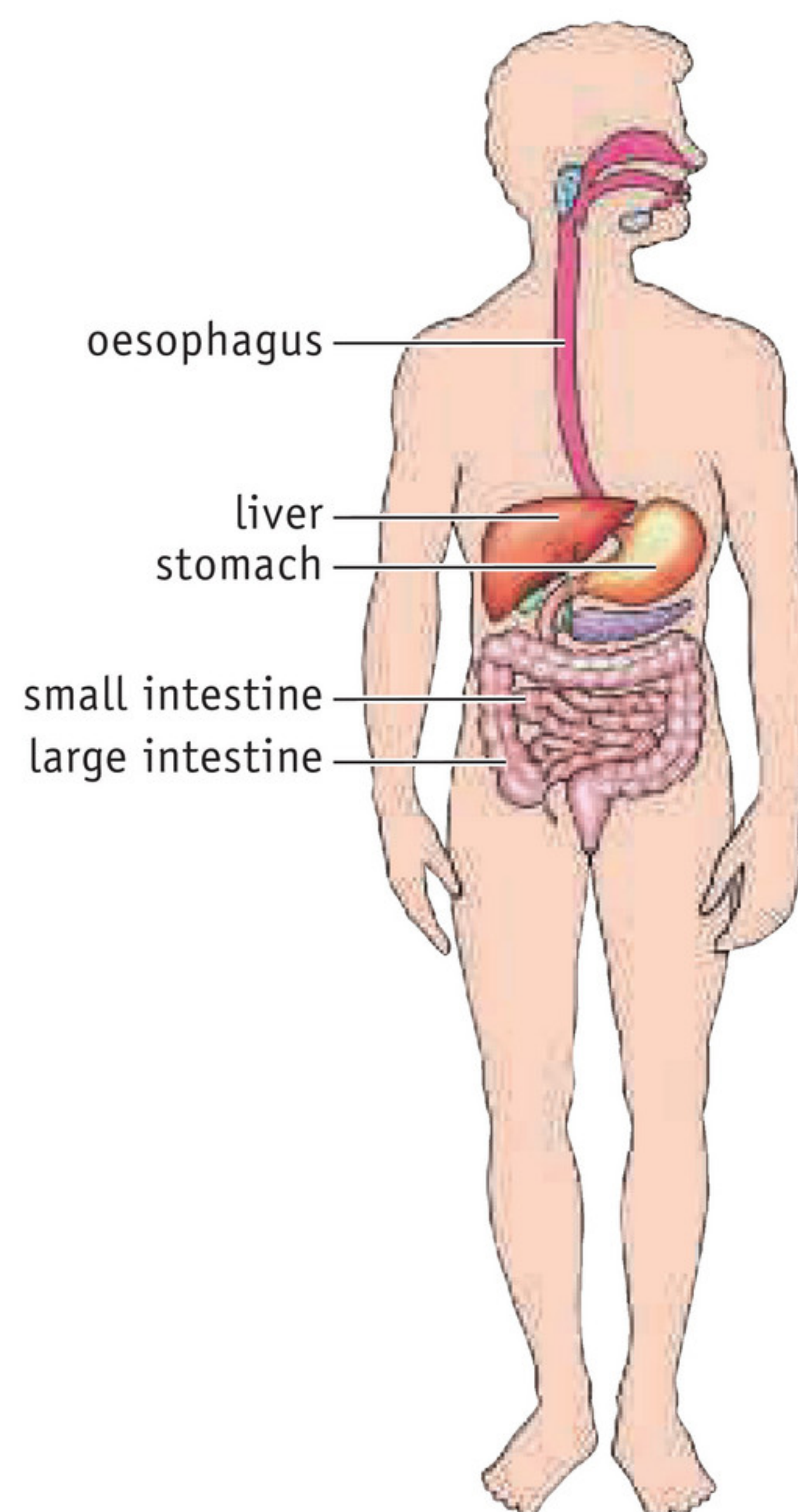
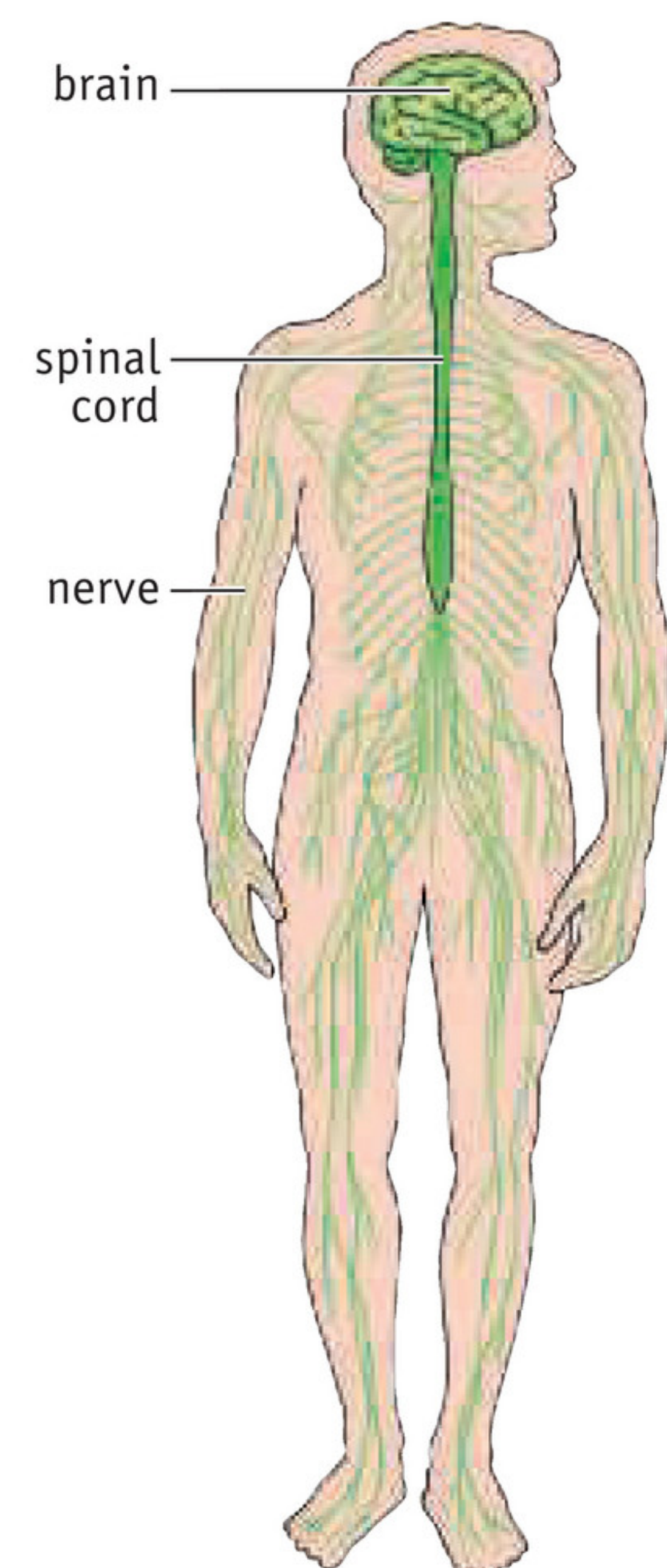
1 Most of the organs are in the torso.



2 Various organs have been removed from the torso.

ORGAN SYSTEM

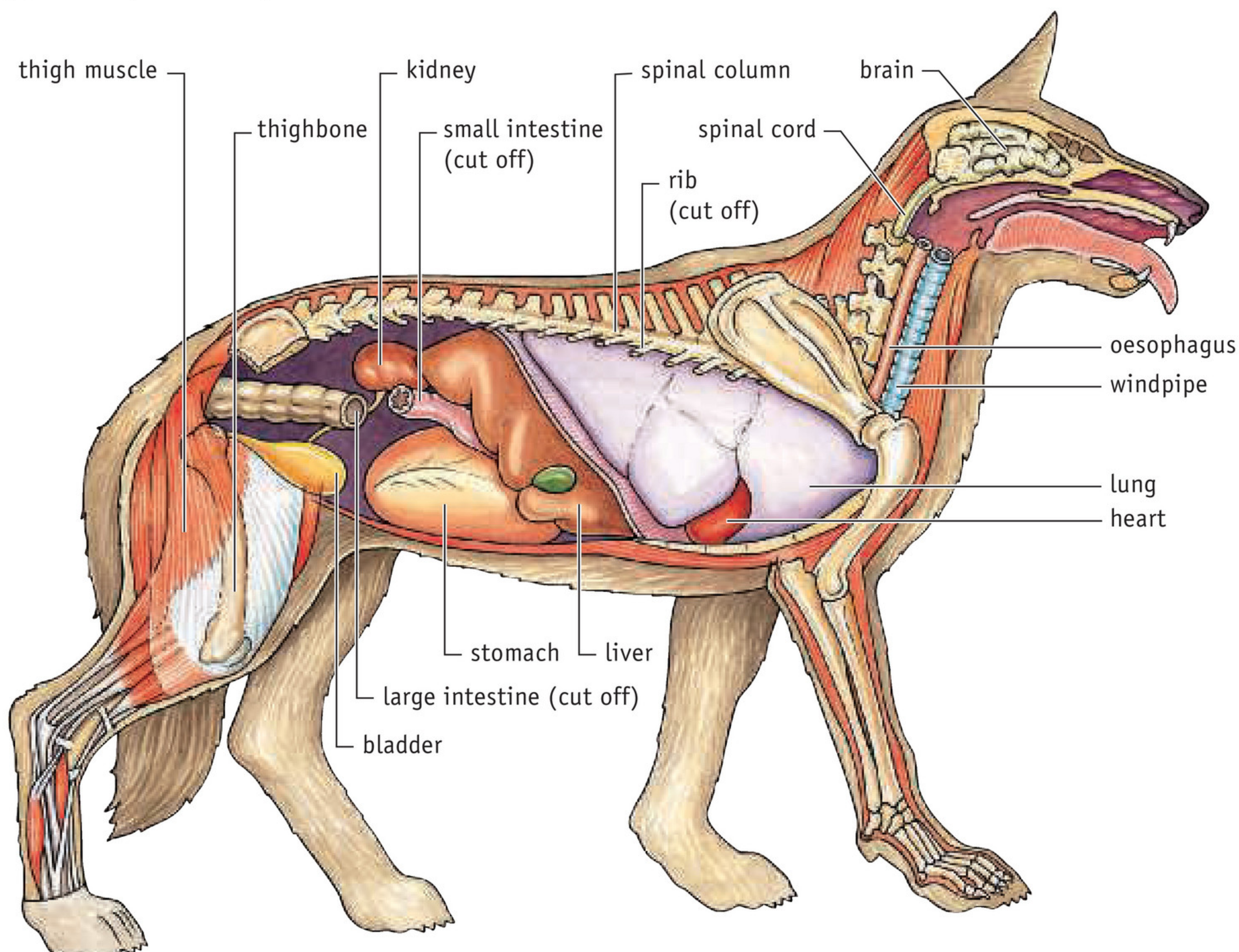
Organs often work together to perform a certain task. We call a group of organs that work together an **organ system**. Your heart and blood vessels together make the circulatory system. The function of the circulatory system is to transport blood through your body. Other organ systems are the respiratory system, the skeletal system, the muscular system, the digestive system and the nervous system. Figure 2 shows the organ systems with the function and main organs of each system.

fig. 2 Organ systems in humans.1 respiratory system
(breathing)2 skeletal system
(support and rigidity)3 circulatory system
(transporting blood)4 muscular system
(moving)5 digestive system
(digesting food)6 nervous system
(transmitting signals)

ORGANS OF ANIMALS

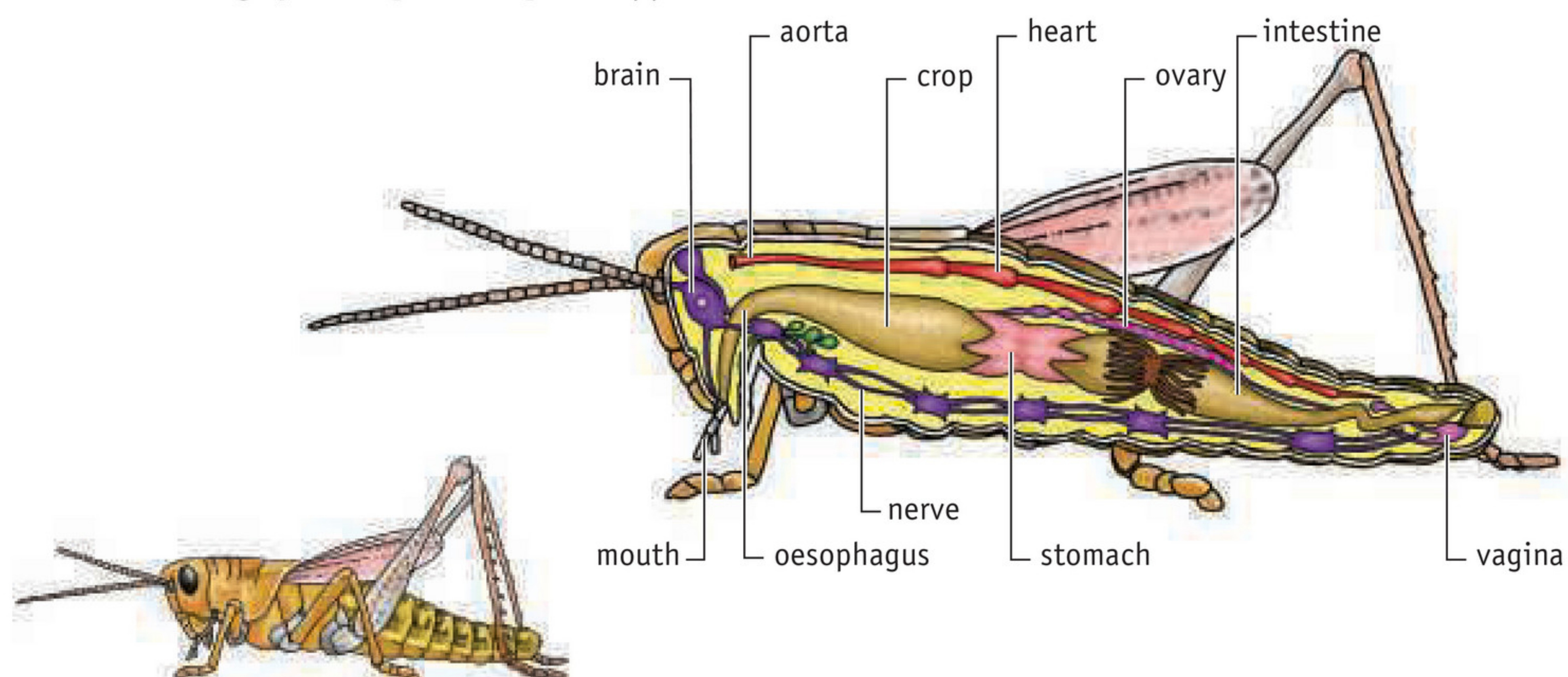
Figure 3 shows some of the organs in a dog. You can see that a dog has the same organs as a human. Most mammals have the same organs as humans.

fig. 3 The organs of a dog.



An insect's body looks very different from the body of a human or a dog, but insects too have organs and organ systems. You can see that in figure 4.

fig. 4 The organs of a grasshopper.



KNOWLEDGE

1

Some parts of a human are listed below.

Which part is an organ?

- ☐ A head
- ☐ B skeleton
- ☐ C tongue
- ☐ D eyelashes

2

Figure 5 shows two drawings of a torso.

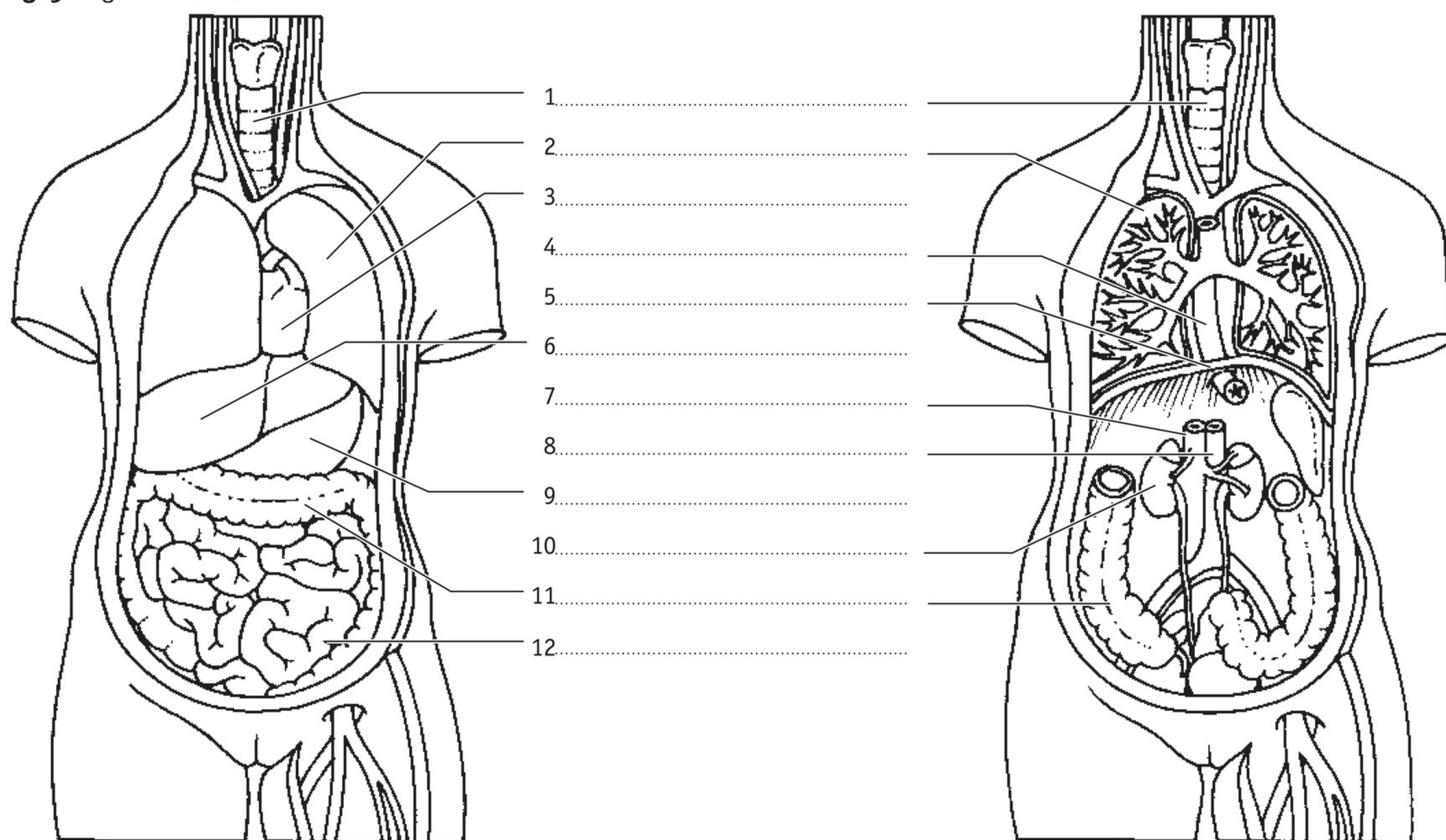
a Write down the names of the numbered organs. Use figure 1.



b Colour in the organs in the drawings. Use a different colour for each organ.

c Which organs in the figure are part of the circulatory system?

fig. 5 Organs in the torso.



3

Which organ system is the organ a part of?

- 1 biceps
- 2 gluteal muscle
- 3 bronchus
- 4 cerebellum
- 5 liver
- 6 radial artery
- 7 spinal column

4



Summary

Make a summary of this Basics section. Do that by answering the questions.

- What is an organ?
- Give six examples of organs in humans.
- What is an organ system?
- Give six examples of organ systems in humans and other mammals.
- For each organ system, give three organs that are part of that system.

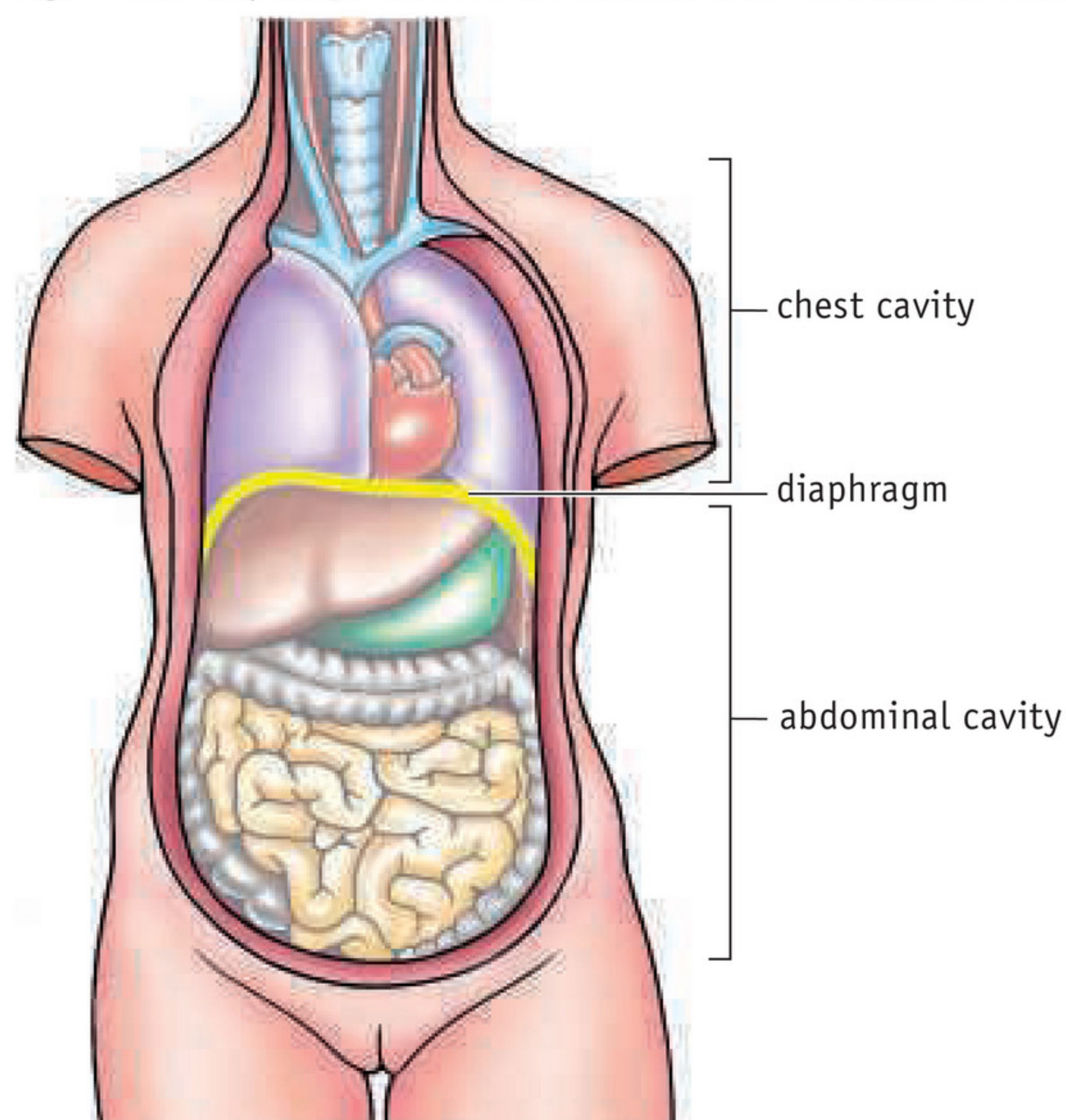
INSIGHT

5

The diaphragm divides the human torso into the chest cavity and the abdominal cavity (see figure 6). The lungs and the heart are in the chest cavity, while the liver for example and the intestines are in the abdominal cavity. Some organs go through the diaphragm.

a Which three organs go through the diaphragm?

fig. 6 The diaphragm divides the human torso into the chest cavity and the abdominal cavity.



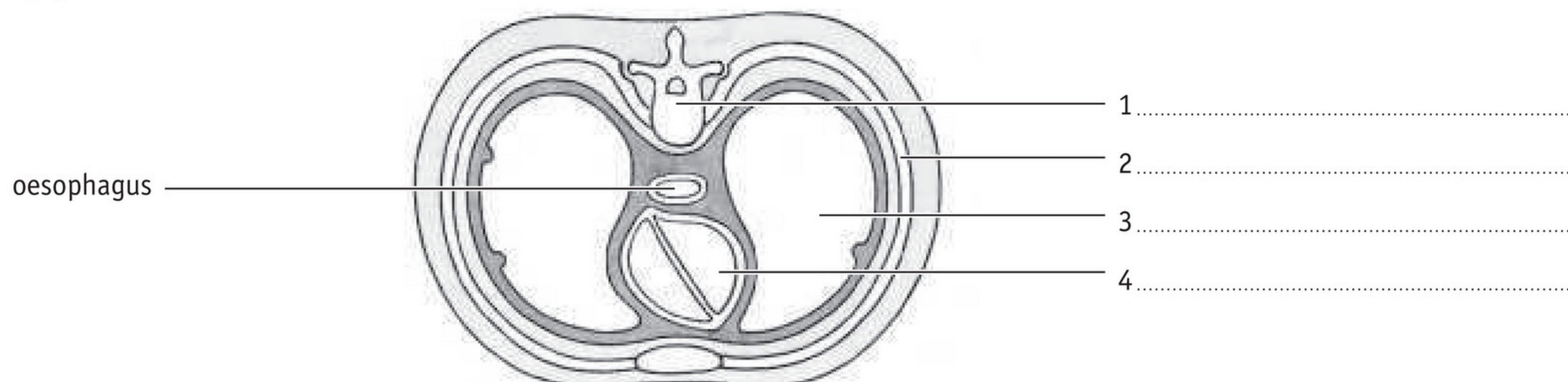
- b** Figure 7 shows three cross-sectional diagrams of the torso. Some organs are labelled with their names but other organs have no labels.

Add the names to the numbered organs.

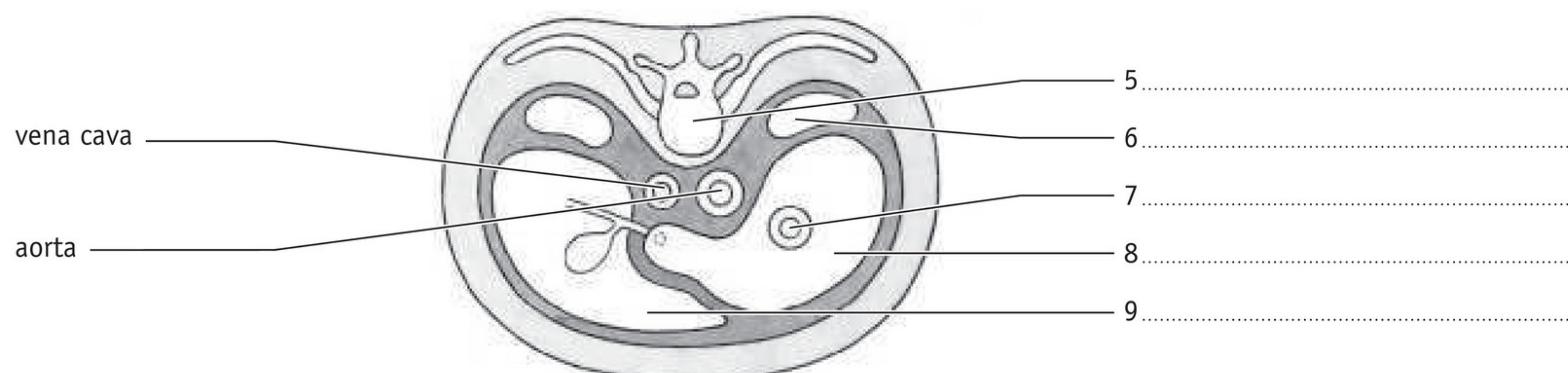


- c** Colour in the organs in the drawings. Use a different colour for each organ system.

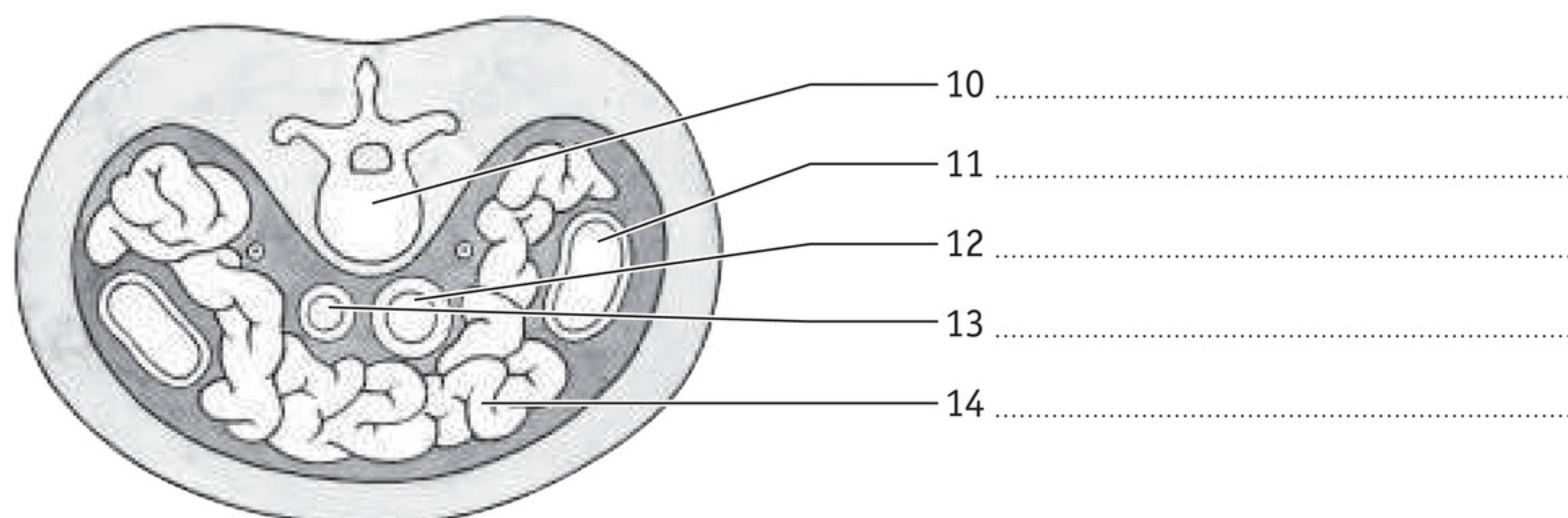
fig. 7



1 cross-section of the chest cavity



2 cross-section of the abdominal cavity, just below the diaphragm



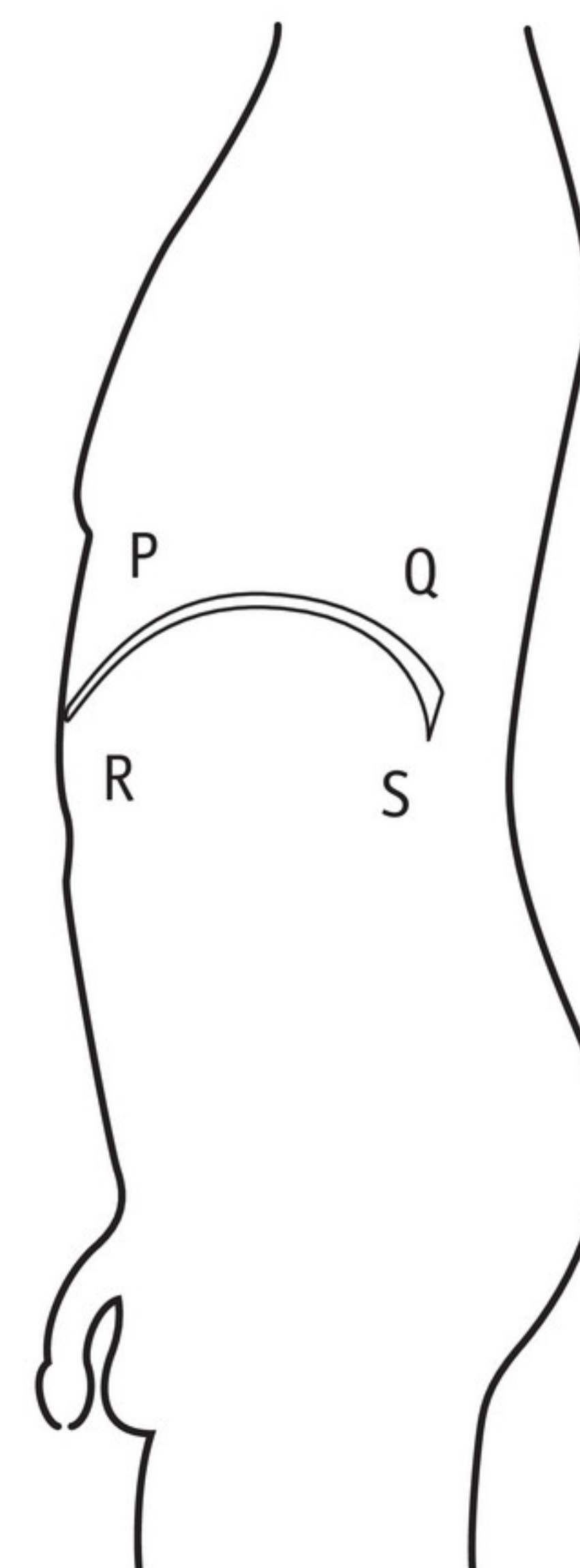
3 cross-section of the abdominal cavity, at the level of the belly button

d Figure 8 shows the torso of a man. Four areas in the torso have been labelled with the letters P, Q, R and S.

Which letter shows the area where the kidneys are?

- ☐ A letter P
- ☐ B letter Q
- ☐ C letter R
- ☐ D letter S

fig. 8 Torso of a man.



+ 6

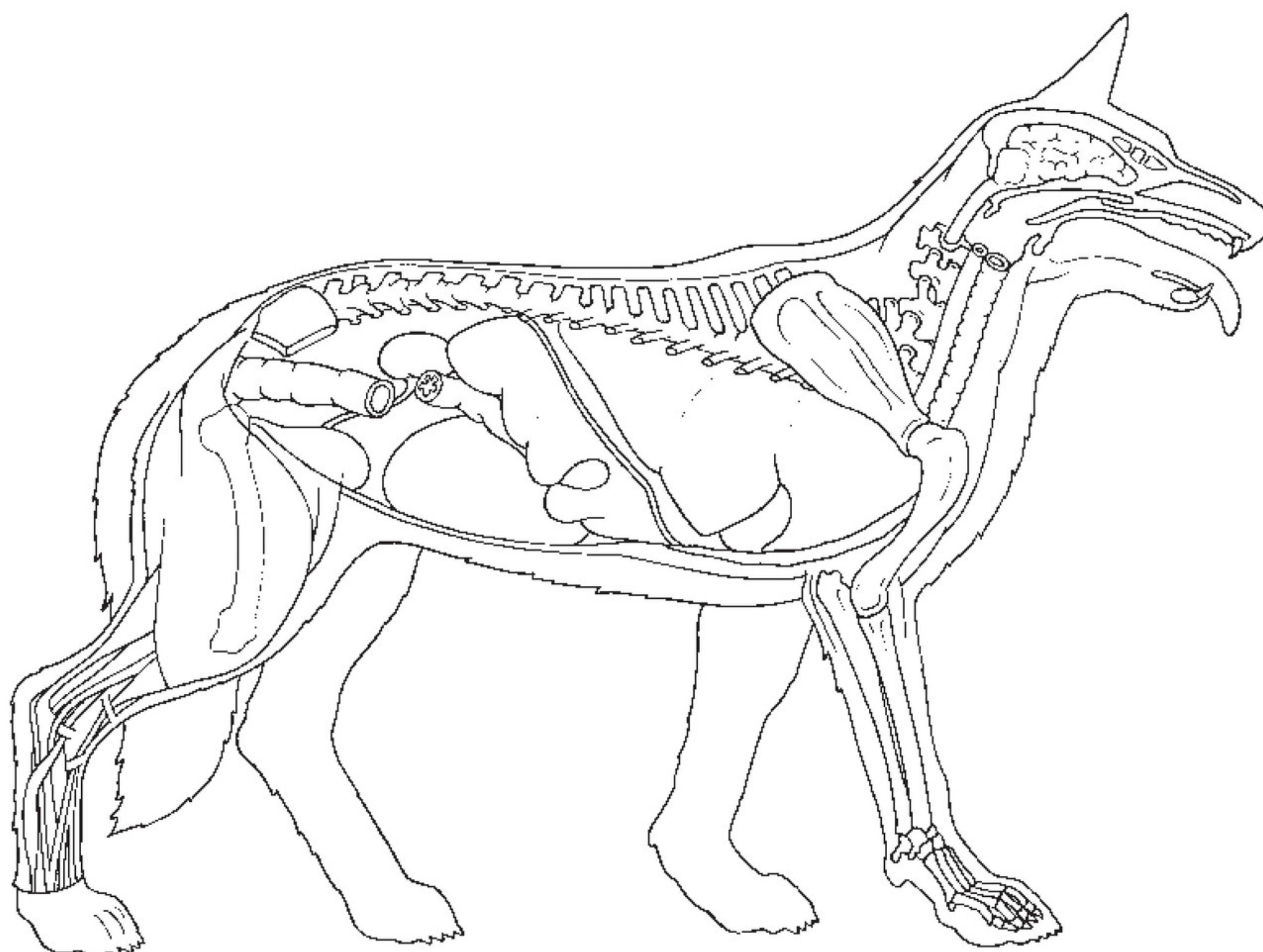


Figure 9 shows the organs in a dog.

Colour in the drawing:

- using yellow for all organs that are part of the skeletal system
- using orange for all organs that are part of the muscular system
- using green for all organs that are part of the digestive system
- using blue for all organs that are part of the respiratory system
- using red for all organs that are part of the circulatory system
- using purple for all organs that are part of the nervous system

fig. 9 The organs of a dog.



HOW IT FITS TOGETHER the living world**ORGANS YOU CAN DO WITHOUT**

The organs in your body carry out tasks that keep you alive, so you can't do without most organs. But you can get by without some organs. For example, if you have an inflamed appendix, part of it can be removed without any problems. And you have two kidneys and two lungs, but you can survive with only one. The entire stomach can be removed in patients who have stomach cancer. Your stomach kneads and grinds up everything you eat and it releases a digestive juice that digests your food to some extent. The rest of the digestion process takes place in the small intestine and the large intestine. Your stomach is definitely a very useful organ but you can actually survive without it.

fig. 10 Model of the stomach.**7**

Read the text 'Organs you can do without'.

- a** Highlight all the organs mentioned in the text.
- b** If a surgeon removes the stomach, they have to put in a new connection between two organs.
Which organs do they have to connect together?
- c** Which organs in the digestive system will take over some of the tasks of the stomach after it has been removed? Explain your answer.

 Go to the *Flash cards* and the *Test yourself* section.

2

The organs of plants

LEARNING OBJECTIVES

- 2.2.3 You can describe the structure and function of roots, stems and leaves.
- 2.2.4 You can name organ systems in plants and list their functions.
- Practical activities 5, 6 and 7

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	2.2.3	2.2.4	1.1.2*
Remembering	1abcd, 2abd, 3a	1abcd, 4a	
Understanding	1e, 2c, 3bc, 4b, 5	1e, 5	
Using	8, 9a	7a	10a
Analysing	6, 7c, 9b, 10bc	7b, 10d	

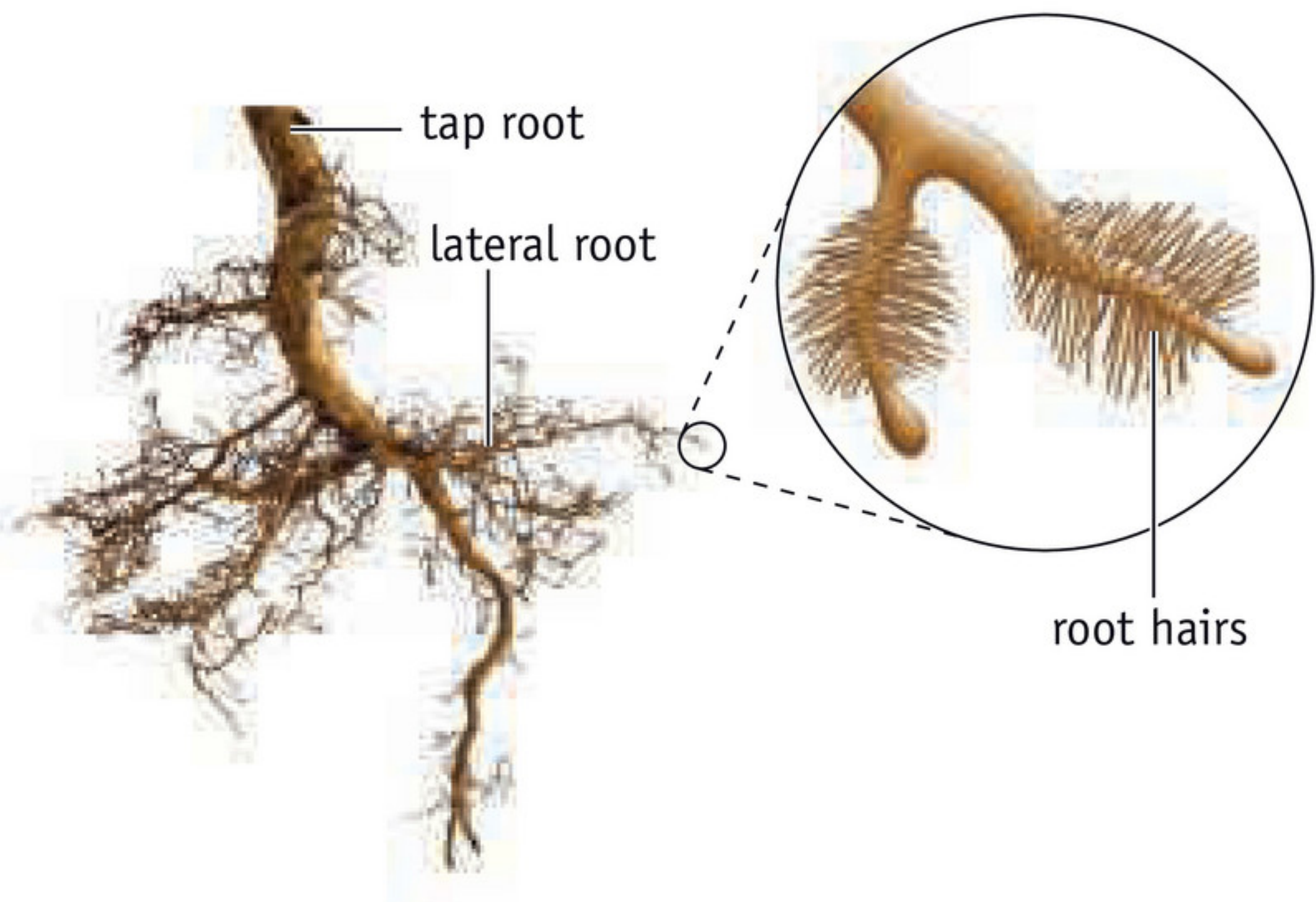
* You can find this learning objective in another unit.

Plants also have organs and organ systems. Roots, stems and leaves are all plant organs.

ROOTS

All plants have roots but the roots of different plants often look different. Many plants have one long, thick **tap root** with **lateral roots off it** (see figure 1). The ends of the lateral roots have **root hairs**.

fig. 1 Tap root with lateral roots and root hairs.



All the roots of a plant taken together are called its **root system**. The root system is an organ system. Trees can have very large root systems, with thick lateral roots snaking over the ground (see figure 2). Bulbs, such as tulips and onions, do not have a tap root or lateral roots (see figure 3).

fig. 2 Part of the root system of a tree.**fig. 3** The root system of a tulip.

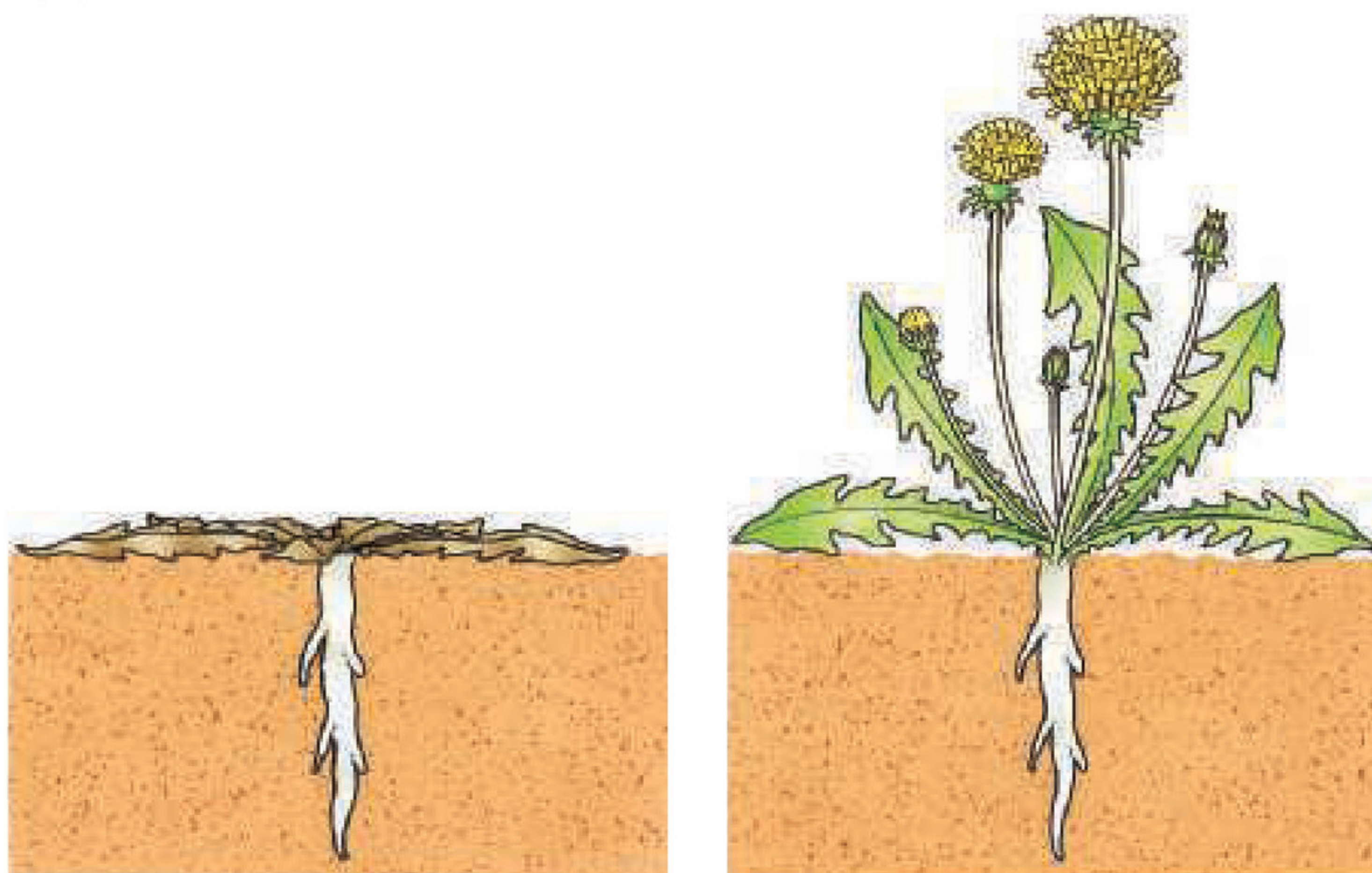
ROOT SYSTEM

A plant's root system has three functions:

- taking up water and minerals from the soil
- keeping the plant firmly anchored in the ground
- storing food reserves

Plants need water and minerals to stay alive. The **minerals** (salts) are nutrients for a plant. They are dissolved in the water in the soil. Plants take up water with minerals from the soil through the root hairs. Because the roots branch out a lot, they also make sure that the plant stays firmly anchored in the soil. A third function of the roots is to store **food reserves**. These are substances that the plant doesn't need immediately. The plant stores them so that it can use them later, for example to grow quickly in the spring. A dandelion does this:

it dies off in the winter but the root stays alive underground. In the spring, a dandelion plant can then grow quickly from the root (see figure 4). To grow, it uses the food reserves in the root. Trees, bushes and other plants also store food reserves in their roots.

fig. 4 Dandelion.

1 in the winter

2 in the spring

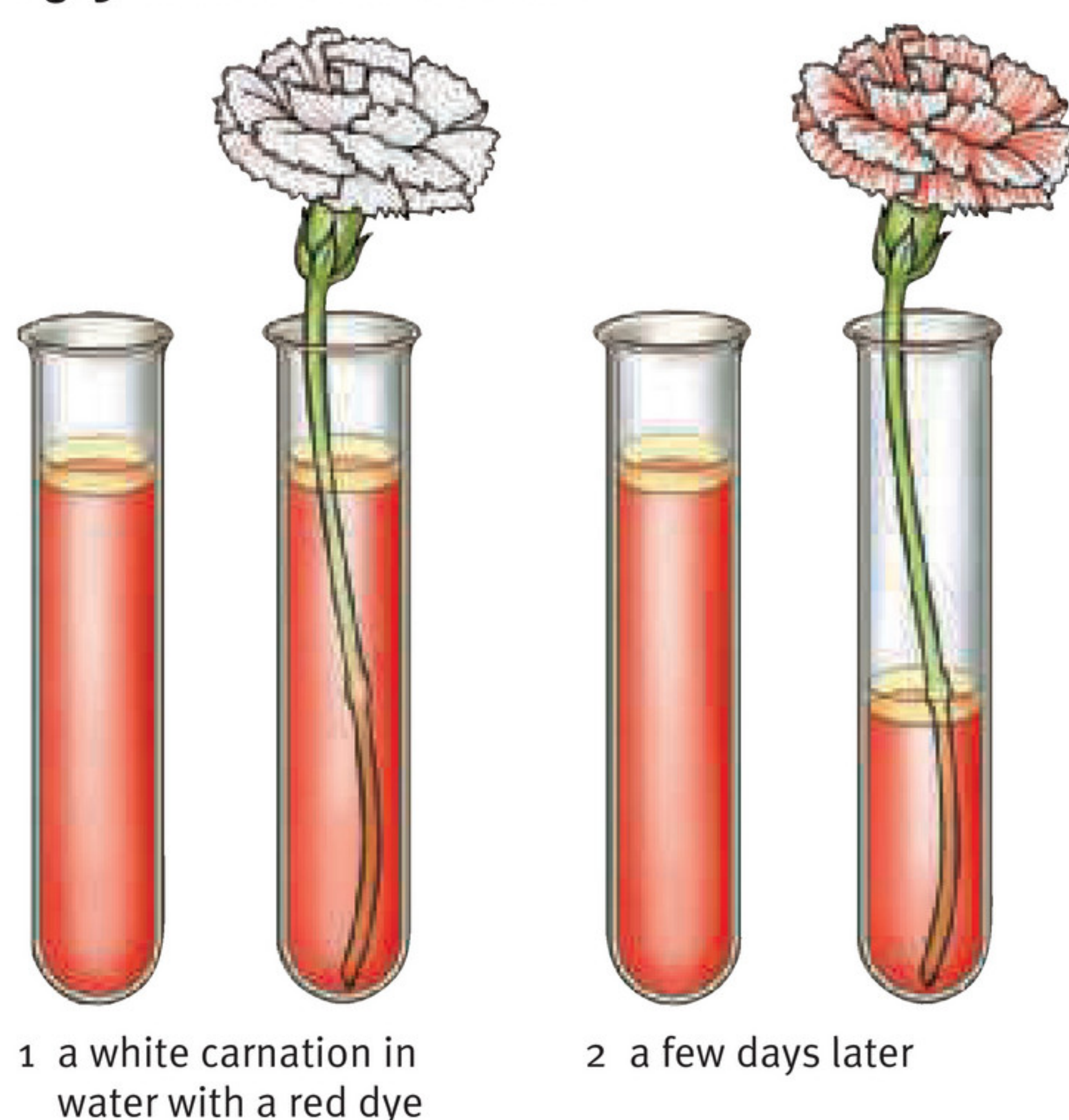
STEMS

The plant has stems between the roots and the leaves. Stems have two functions:

- to transport substances
- to give the plant rigidity (make it sturdier)

Water and minerals travel from the roots through the stem to the leaves. Glucose from the leaves travels through the stem to other parts of the plant. So a plant's stem is responsible for transporting substances. You can demonstrate this function of stems in an experiment. Place the stem of a white flower in water containing a red dye. The other test tube is a control, to check that the water is not evaporating from the test tube. Figure 5 shows the result after a few days. Conclusion: the stems are transporting water, along with the dissolved dye.

fig. 5 The functions of stems.



Stems also make the plant more rigid. Trees and shrubs have very sturdy stems: the trunks and branches. These are stems that contain a lot of wood. Trees and shrubs are therefore called **woody plants**. The stems of other plants contain almost no wood. They are called **herbaceous plants**. The stems of herbaceous plants stay rigid as long as the roots can take up enough water (see figure 6).

fig. 6 The leaves and stems of a herbaceous plant will wilt if they do not get enough water.



LEAVES

A leaf consists of a leaf stalk and a blade (see figure 7). The **leaf stalk** is where the leaf is attached to the stem. The flat part of the leaf is called the **blade**. The **veins** of the leaf can be seen in the blade. The main vein usually runs down the centre of the leaf. The veins branching off are called lateral veins. The veins give the leaf rigidity and transport water and other substances. The parts between the veins are called the **lamina**.

fig. 7 A leaf.

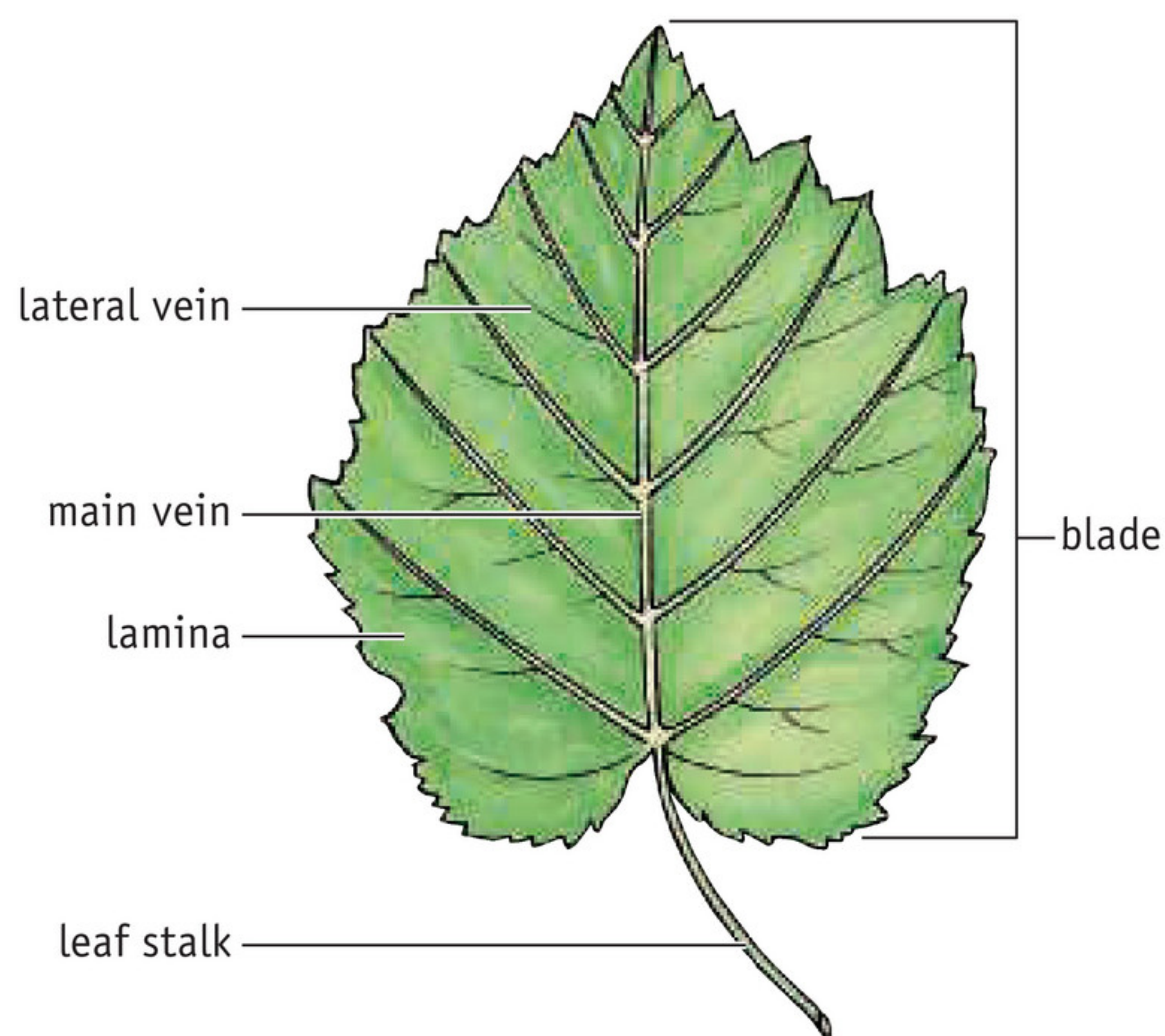
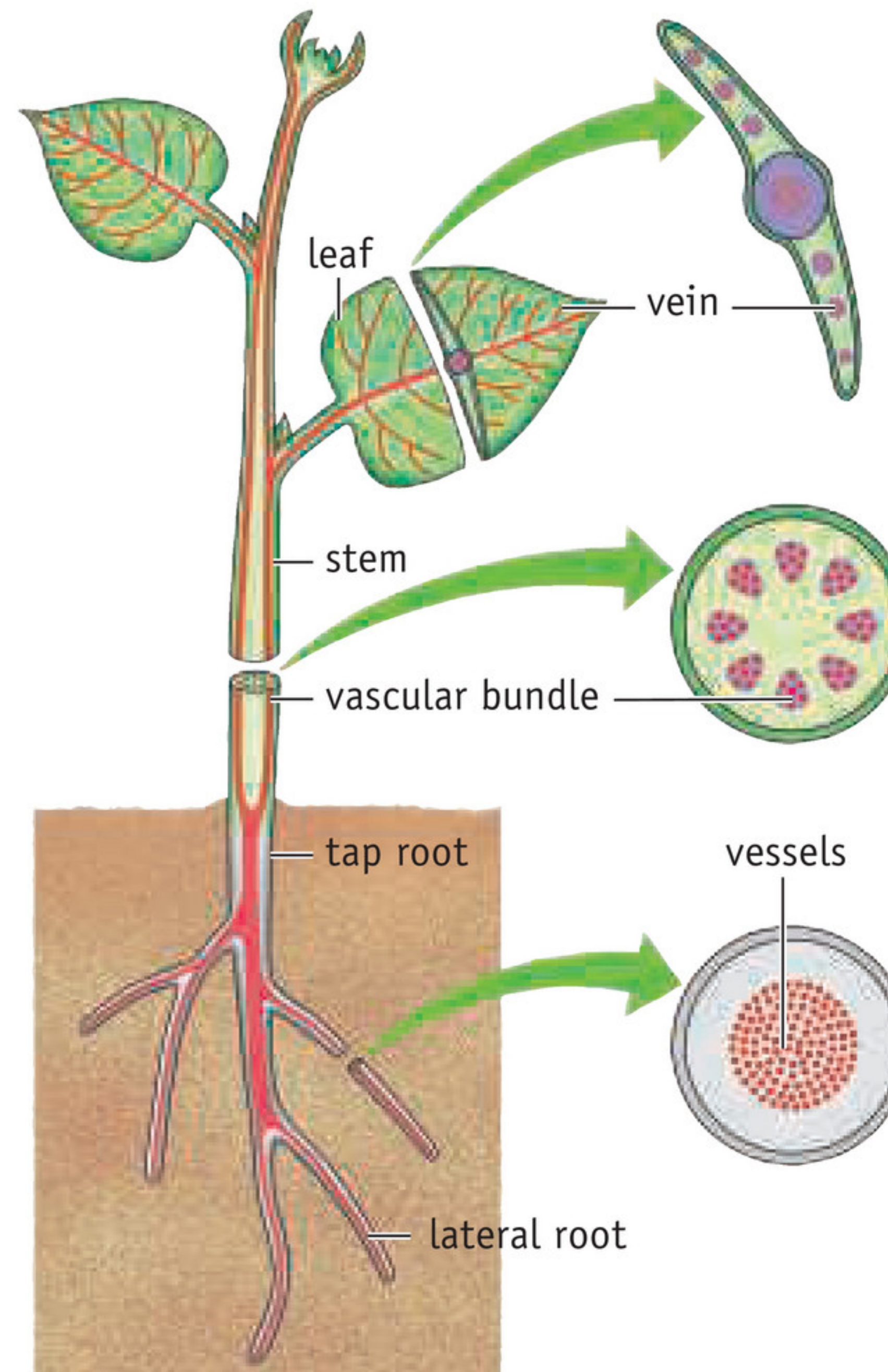


fig. 8 A plant's vascular system.



The function of the leaves is to make food for the plant. That is done by photosynthesis. Photosynthesis takes place in all the green parts of a plant. So plants with green stems are also photosynthesising in the stems, though it mostly happens in the leaves. Water is needed for photosynthesis. A plant's roots take up water from the soil. The water reaches the lamina via the stem and the veins.

VASCULAR SYSTEM

A stem has long thin tubes running through it, known as **vessels**. In some plants, these vessels are grouped closely together. A group like that is called a **vascular bundle**. These bundles of vessels start in the roots and run up the stem to the leaves (see figure 8). The veins in the leaf also consist of vascular bundles.

All the vessels of a plant taken together are called its **vascular system**. The function of the vascular system is transport:

- water and minerals travel from the roots to the other parts of the plant
- glucose travels from the leaves to the other parts of the plant

KNOWLEDGE

1

Roots are plant organs.

- What does a root system consist of?
- Many plants have a root system with one long, thick plus a number of
- Which part of the root system does a plant take up water with dissolved minerals from the soil through? *tap root / lateral roots / root hairs*
- Which property of roots keeps a plant firmly anchored in the soil?
- Explain when a plant uses food reserves.

2

One function of the stems is to make the plant more rigid.

- The stems of *woody / herbaceous* plants stay firm as long as the roots are able to take up enough water.
- The stems of trees and bushes are rigid because they contain a lot of
- A stem with a white flower is put in water that a blue dye is dissolved in. After a while, the flower turns blue.
What function of stems has this shown?
- What does the stem transport from the leaves to other parts of the plant?

3

Leaves consist of various parts.

- Write in the correct names.
 - the flat part of the leaf
 - this is where the leaf is attached to the stem
 - they add rigidity and transport substances
- The roots take up water from the soil for photosynthesis.
What part of the leaves does the water eventually end up in?
- In which parts of a plant can photosynthesis take place? *leaves / stems / roots*

4

The vascular system is a plant organ system.

- and dissolved travel via the vascular system from the roots to the other parts of the plant.
- Figure 9 shows a cross-section of the stem of a sunflower.
What is the circled part called?

fig. 9 Cross-section of the stem of a sunflower.



5

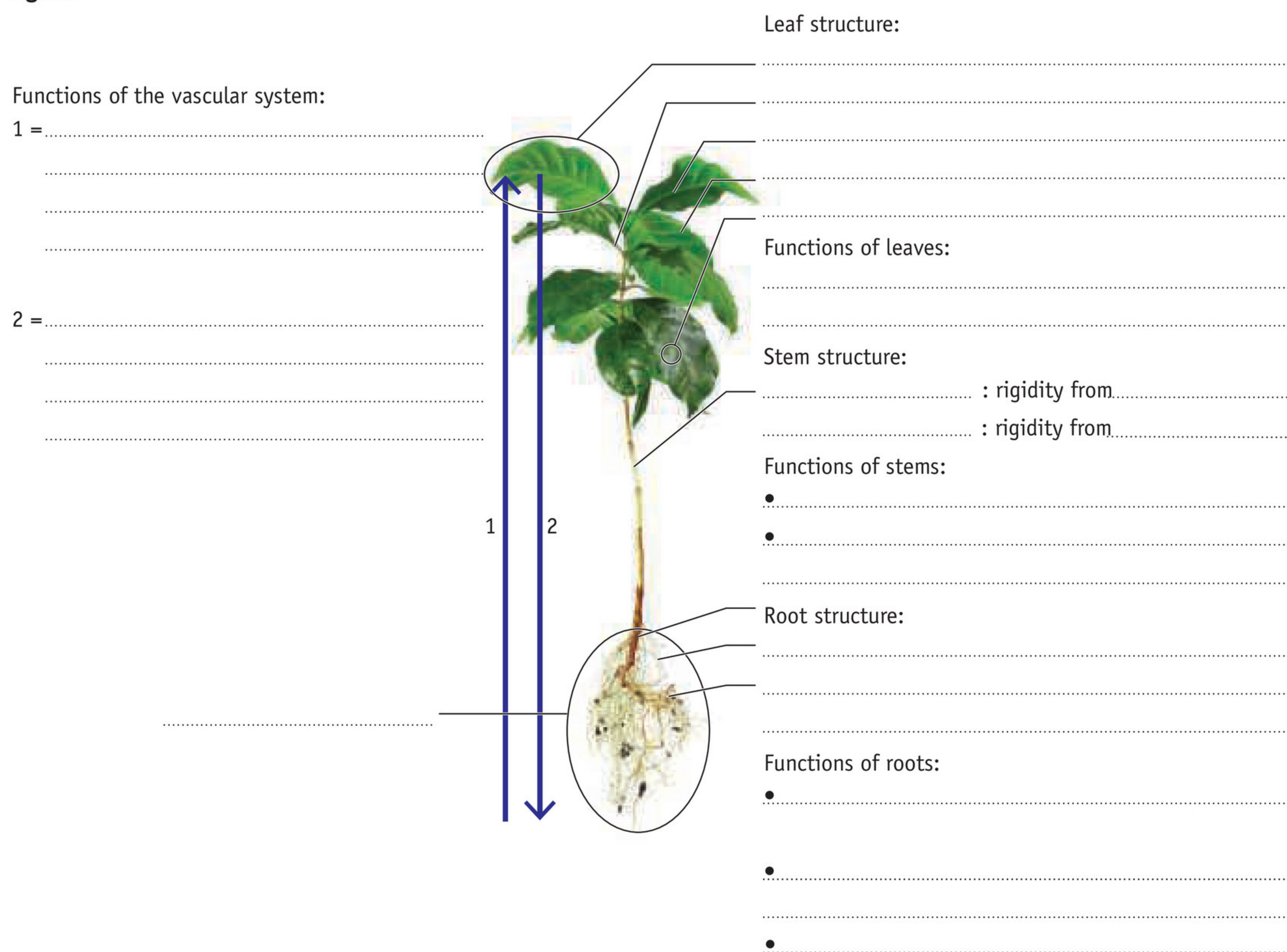
Summary

Figure 10 shows you an infographic about a plant.

Make a summary of this Basics section by filling in the missing texts.



fig. 10

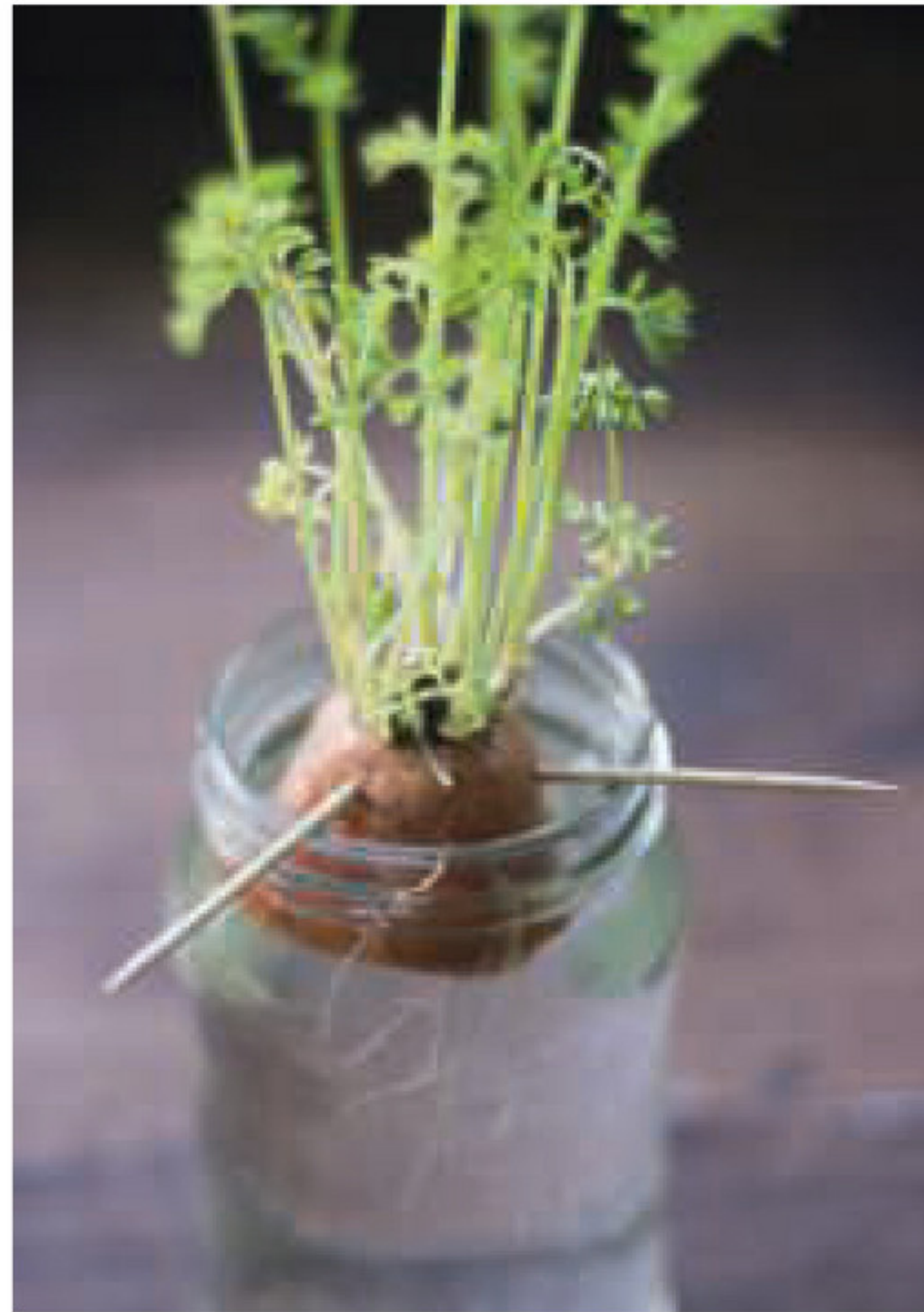


INSIGHT

6

Petra has bought a tomato seedling and planted it at home in a large pot with soil. She puts the plant in the sun and keeps giving it enough water. After a while, tomatoes grow on the plant. When the plant has finished flowering, Petra takes the plant out of the pot. She buys a new tomato plant and puts it in the same pot with the same soil. She puts the second plant too in the sun and keeps giving it enough water. Although the second plant is healthy, it doesn't grow so well.

- a** Why doesn't the second plant grow so well? Explain your answer.
- b** Petra finds she likes gardening and now she buys a small apple tree from a garden centre. She buys the tree with its root system in a ball of soil (see figure 11). Explain why an apple tree with its roots in a ball of soil has more chance of surviving than an apple tree without any soil around its root system.
- c** Petra sees on a website about growing plants that you can get the stems and leaves of a carrot to grow back by suspending the carrot top in water using cocktail sticks. Petra carries out this experiment. You can see the result in figure 12. Where do the nutrients come from that are needed to form new stems and leaves? Explain your answer.

fig. 11 A ball of soil on a tree.**fig. 12** Stems and leaves growing from the top of a carrot.

7

Read the text 'Pancakes with maple syrup'.

- a** Which organ system of the tree does the sap that is tapped flow through?
- b** The transport of sap (the sap flow) in a tree goes in two directions: a flow from the roots to the leaves and a flow from the leaves to the other parts of the tree. Which sap flow is the tapped sap from?
the flow from the *roots to the leaves* / *leaves to the other parts of the tree*
- c** A maximum of three tapping holes are made depending on the size and vitality of the maple tree.
Explain why they don't make more tapping holes.

fig. 13

Pancakes with maple syrup

In Canada and America, people like to eat pancakes with maple syrup for breakfast. Maple syrup is made from the sap of the maple tree, sap that is rich in sugar. A split or hole about 5 cm deep is cut into the trunk of the tree. A tube is inserted into the tapping hole to draw off the sap (see the photo). This sap is then boiled, which makes a lot of the water evaporate, leaving a higher concentration of sugar in the syrup.



8

Figure 14 shows four test tubes, each with a stem and leaves in. Test tubes 1 and 3 contain water but test tubes 2 and 4 don't.

The plant in test tubes 1 and 2 is *woody / herbaceous* and gets its rigidity from *wood / water*. The plant in test tubes 3 and 4 is *woody / herbaceous* and gets its rigidity from *wood / water*.

fig. 14 Rigidity of stems.



+ 9

Figure 15 shows a leaf skeleton. You find leaf skeletons in the autumn in amongst the leaves that have fallen from the trees.

- a** Which parts of the leaf do you see?
- b** If you look at the diameters of the veins in the leaf skeleton, you will see that the thicker veins branch out into thinner and thinner veins.
What is the function of these branching veins?

fig. 15 A leaf skeleton.



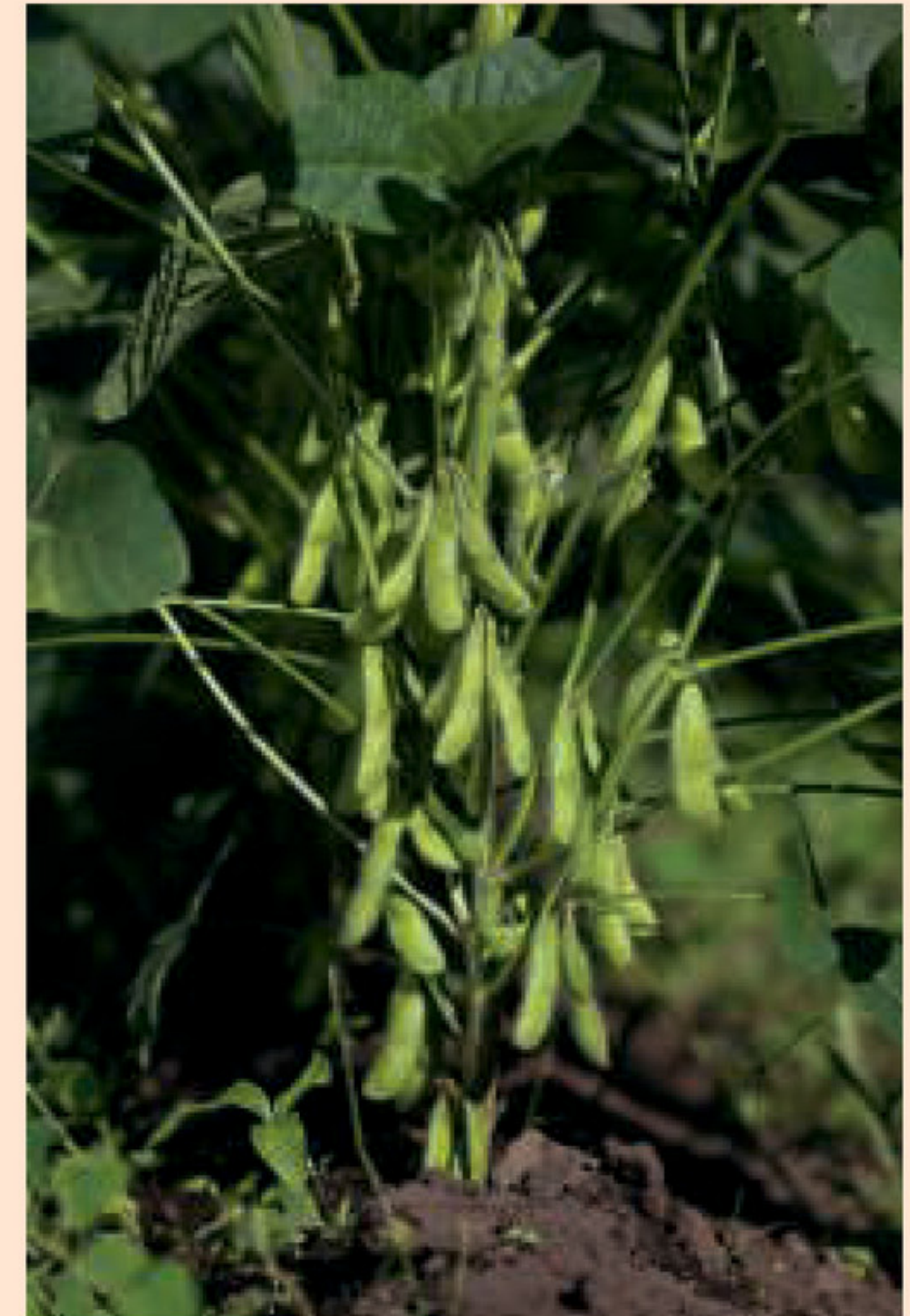
HOW IT FITS TOGETHER science

PLANTS RESPOND TO COMPETITORS

In nature, plants are rarely on their own. They usually grow in an environment with lots of other plants. Research shows that plants respond to competition. If they are very close together, they respond to the shadows from other plants by growing longer, thinner stems. This means that the leaves are higher up the stem.

Plants respond to the presence of other plants underground too. In one greenhouse experiment, soya plants were all given the same amounts of soil, nutrients and water. Some soya plants were in their own pots but others shared a pot. After 110 days, the plants were harvested. The experiment showed that the plants that had shared a pot had larger roots and fewer seeds than soya plants that had their own pots.

fig. 16 A soya plant.



10

Read the text “Plants respond to competitors”.

- a** Which three processes of life does a plant need in order to respond to competitors?
breathing / moving / growing / excreting / feeding / reproducing / sensing
- b** Plants that grow in an environment with dense plant growth and therefore have longer and thinner stems than other plants of the same species, also have fewer leaves.
Explain why.
- c** Why does a plant in an environment with dense plant growth grow better if the leaves are higher up the stem than in other plants of the same species in this environment?
- d** Soya plants that share a pot develop bigger root systems.
What advantage does this have for a plant in this situation?

 Go to the *Flash cards* and the *Test yourself* section.

3 Tissues

LEARNING OBJECTIVES

- 2.3.5 You know that an organism consists of cells.

2.3.6 You can name tissues in humans and plants, along with their functions.
- Learning how to do research 3

► Practical activities 8 and 9

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	2.3.5	2.3.6	2.2.3*
Remembering		2, 3ab, 4a	
Understanding	1, 5	3c, 4bc, 5	
Using	6, 10a	6, 8, 10abc	10b
Analysing		7, 9, 10de	

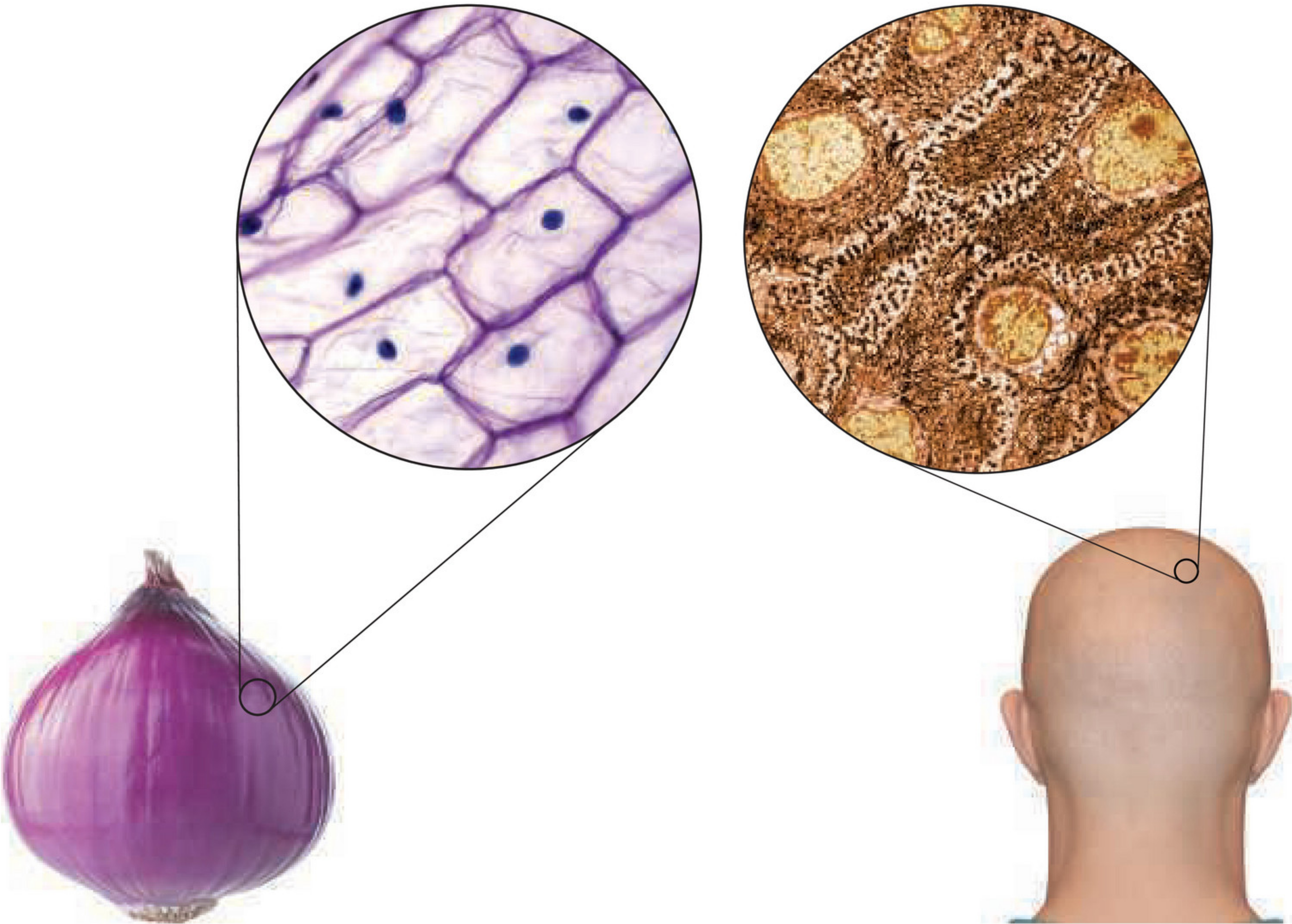
* You can find this learning objective in another Basics section.

Cells are the building blocks of organisms. Your body consists of various types of cells.

CELLS

All organisms consist of one or more cells. **Cells** are the building blocks of an organism. Cells are so small that you can only see them under a microscope (see figure 1). A human body has as many as 30 trillion cells. That is 4,000 times as many cells as there are people on the planet!

fig. 1 Cells under the microscope (the photos were made using a ‘stain’ – a kind of dye).

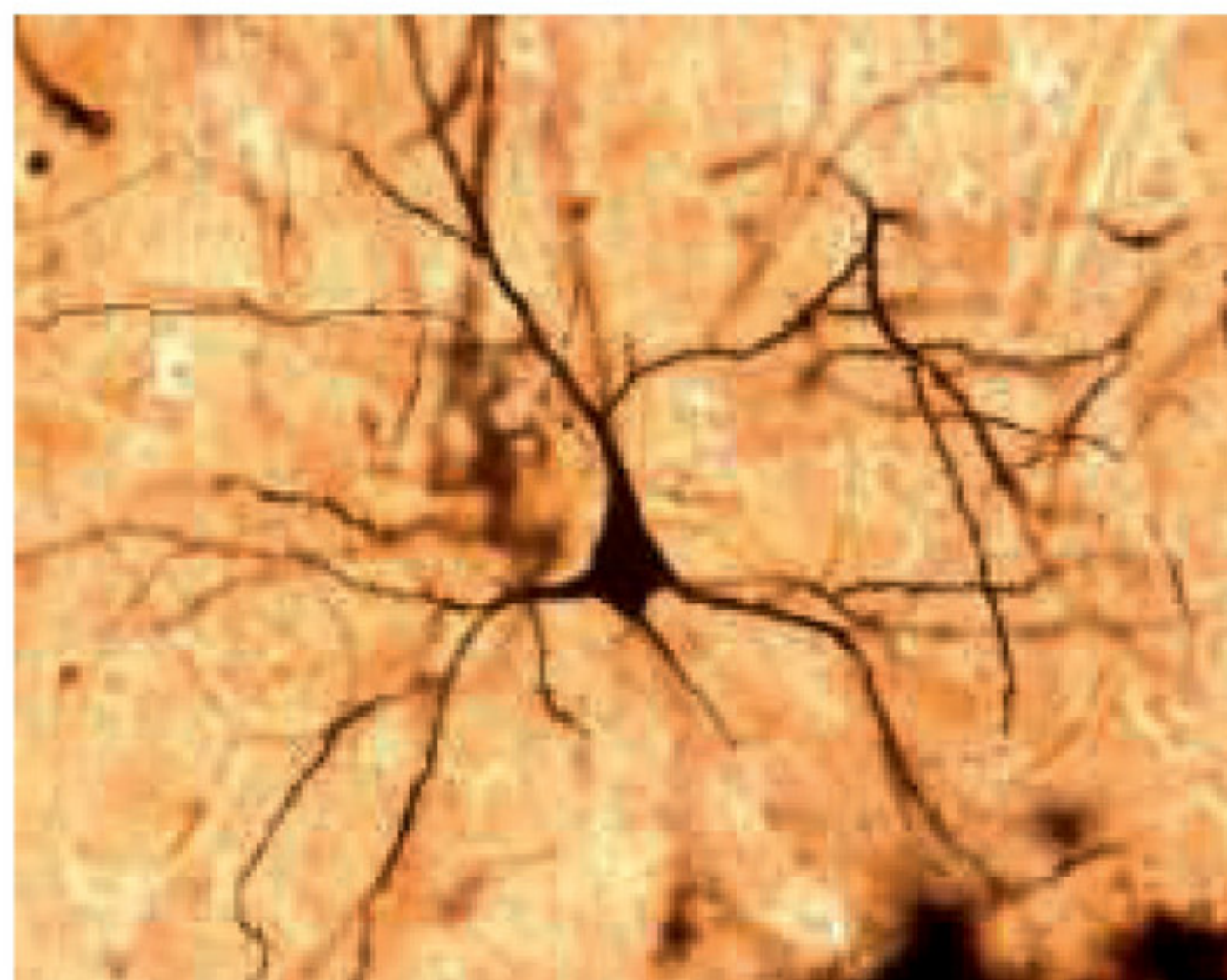


1 cells in the skin of an onion

2 cells in the skin of a human

Cells look flat when seen under a microscope, but they are not really. Cells come in all kinds of shapes, such as balls or cubes. Some cells have protrusions that stick out (see figure 2).

fig. 2 A nerve cell with protrusions (called 'dendrites' for nerve cells).

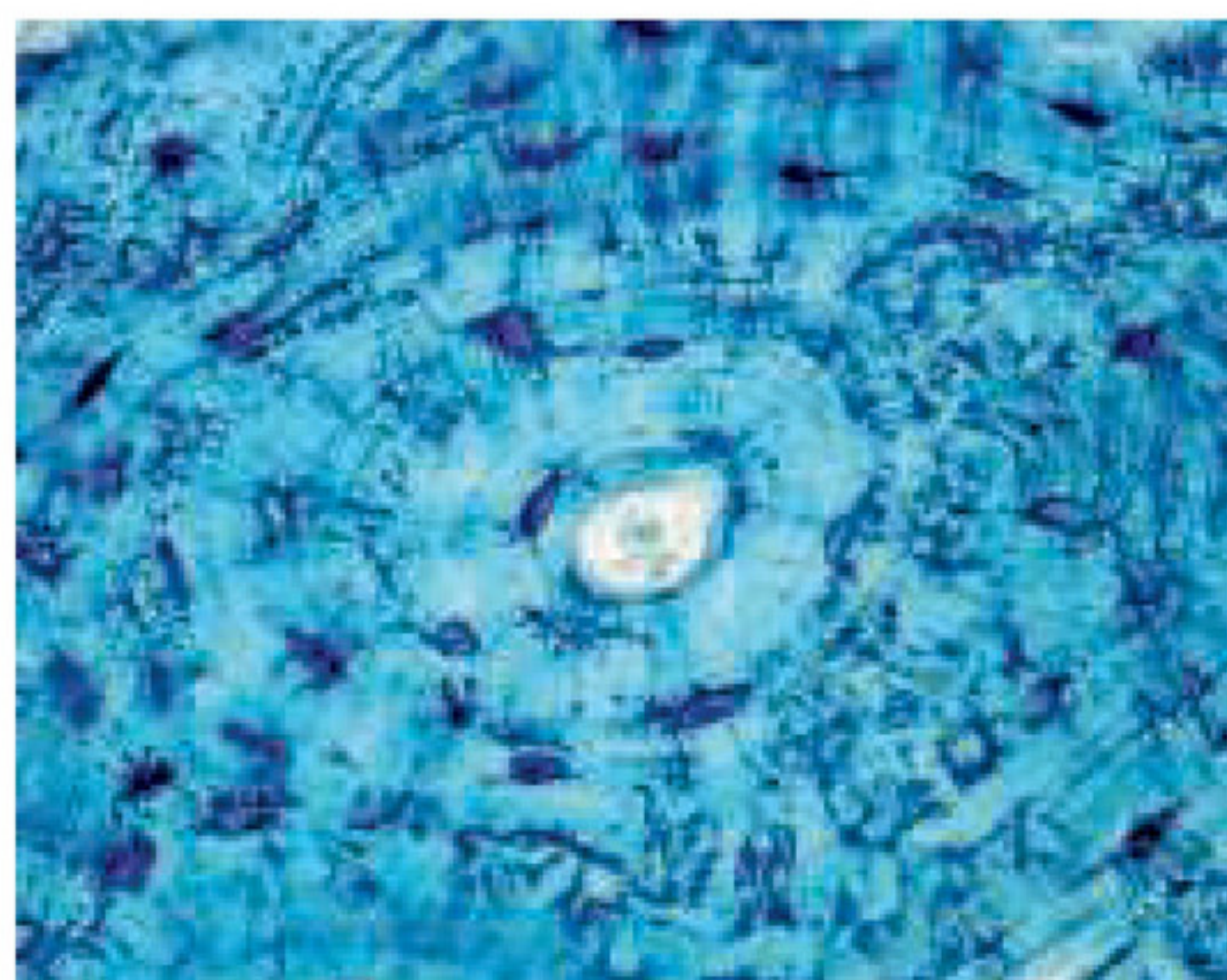


HUMAN TISSUES

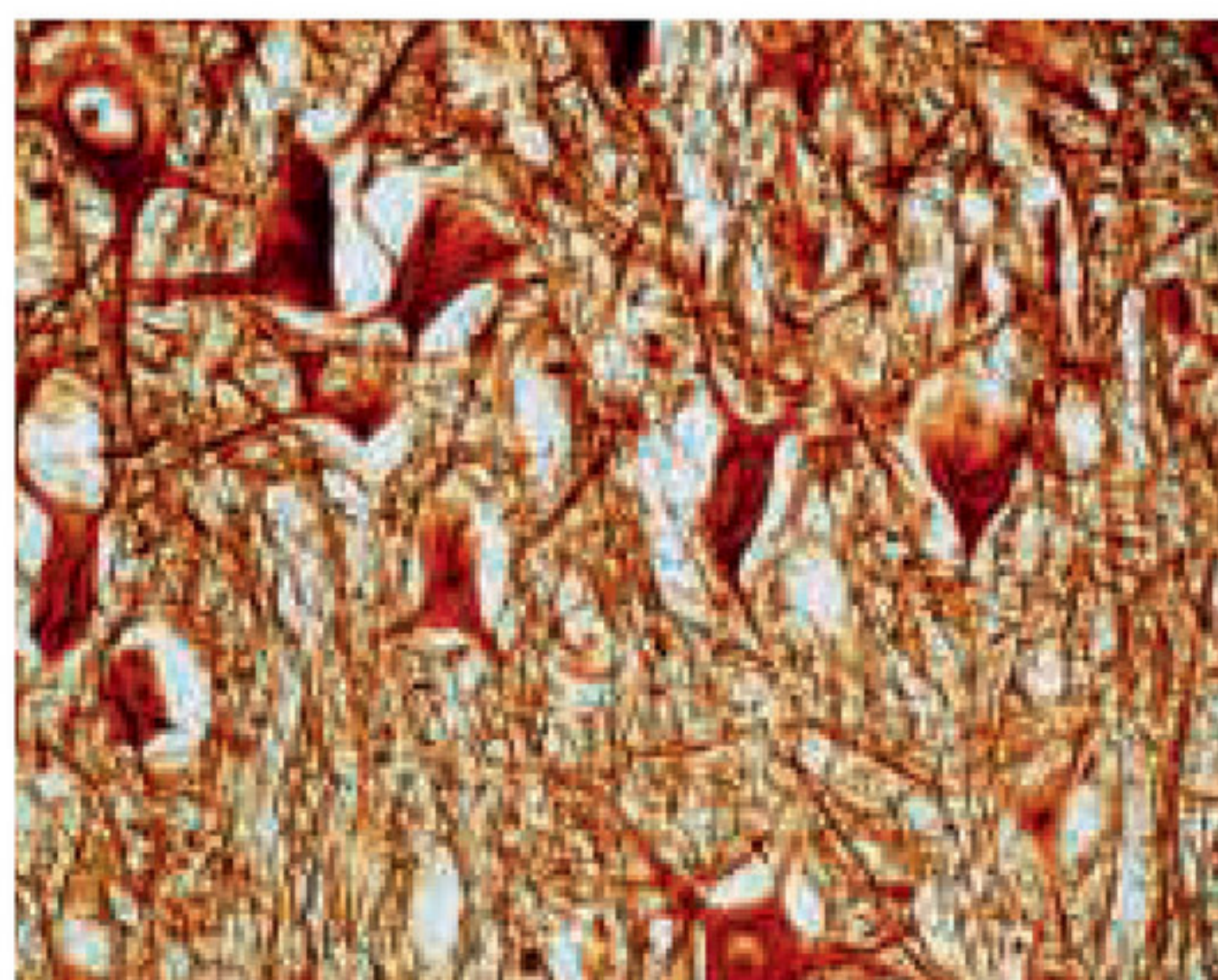
Cells of the same type are often found clustered together. Groups of cells with the same shape and function are called **tissues**. For example, the bones in your body are made up mostly of bone cells. Together, the bone cells form bone tissue (see figure 3.1).

An organ often consists of different tissues. Your heart, for example, contains muscular tissue and nervous tissue. The brain also contains nervous tissue (see figure 3.2) and your muscles have muscular tissue (see figure 3.3).

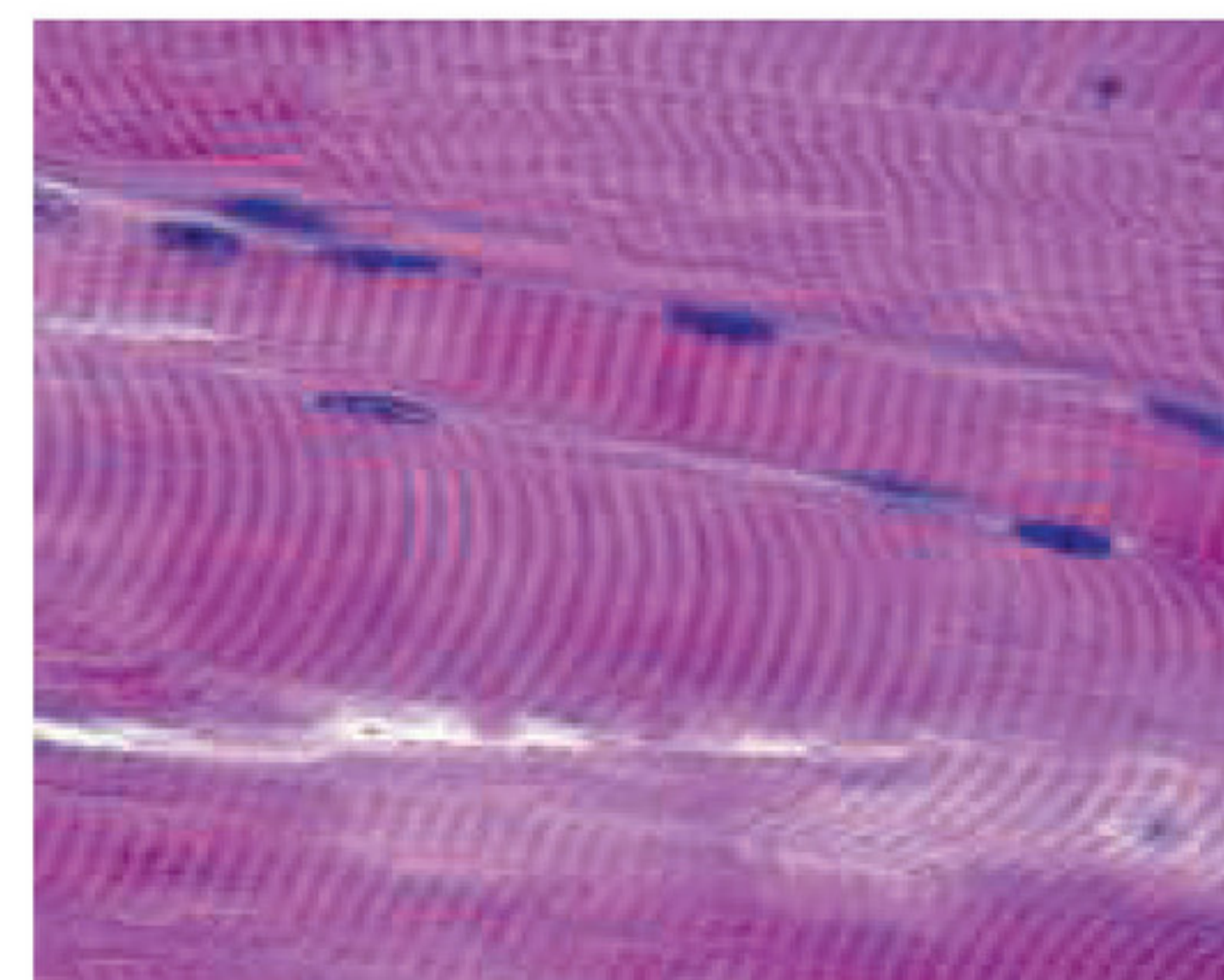
fig. 3 Tissues (microscope photographs, stained).



1 bone tissue



2 nervous tissue

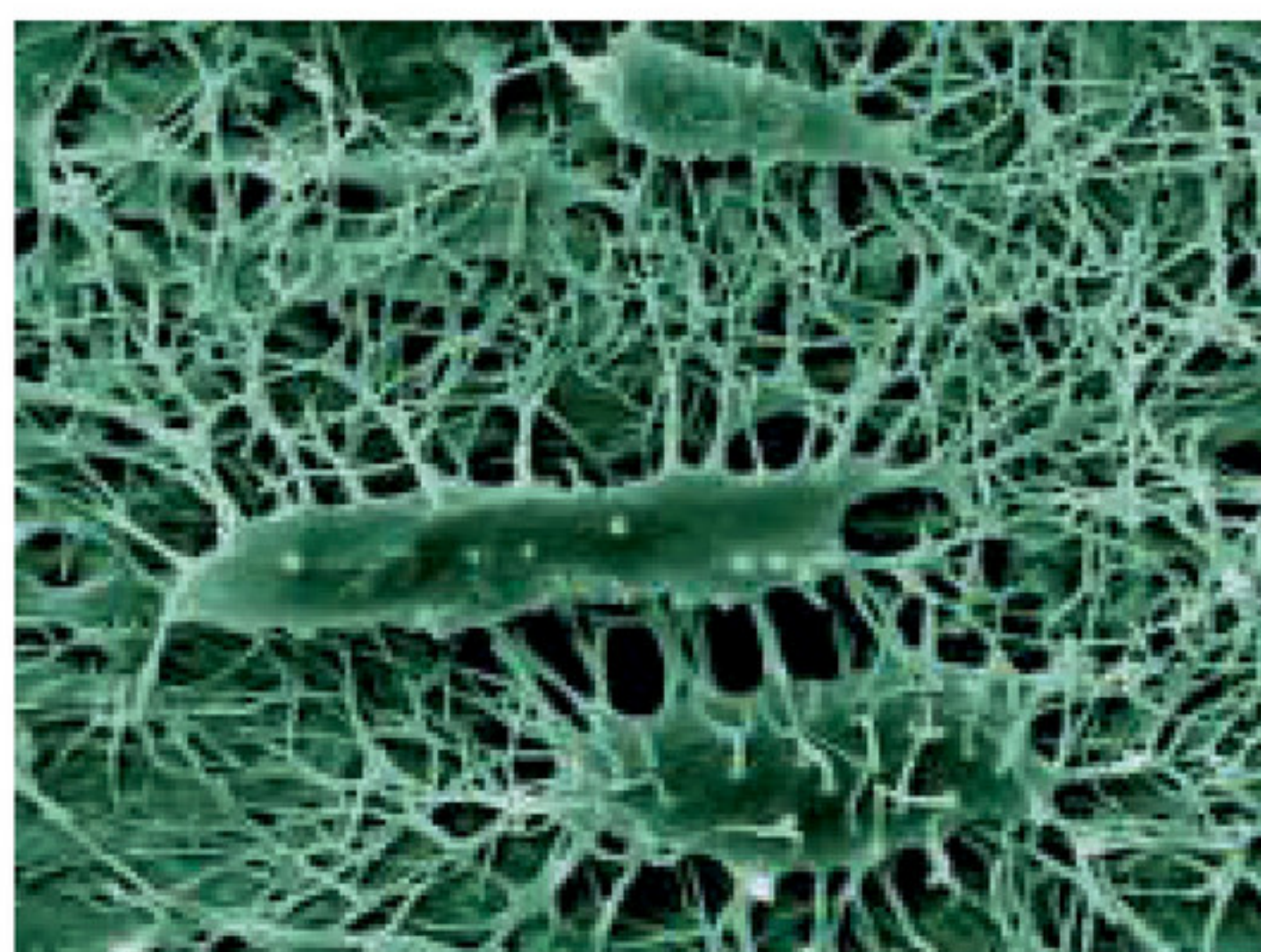


3 muscle tissue

EXTRACELLULAR MATERIAL

Many tissues have **extracellular material** between the cells. There are various types of extracellular material. Sometimes it is a liquid, such as the cerebrospinal fluid between the nerve cells in the brain. Sometimes it is a hard material made by the tissue cells. For example, bone cells make a limestone-like substance as extracellular material. The bone cells themselves are connected to one another by protrusions (see figure 4). The extracellular material and the protrusions make the tissue rigid and strong.

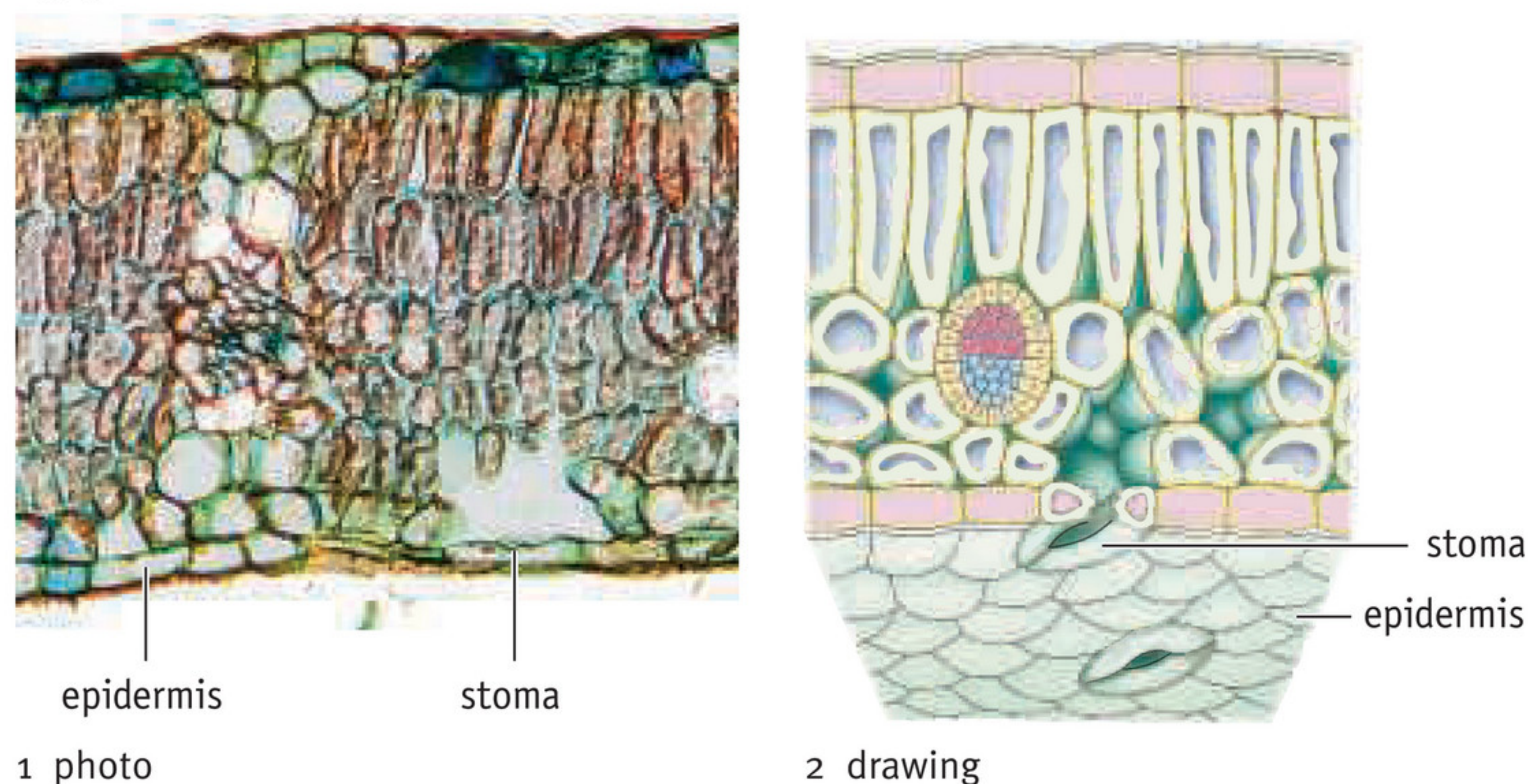
fig. 4 Bone cells with protrusions in the bone tissue.



PLANT TISSUES

Plant organs also consist of tissues. Figure 5 shows a photo and a drawing of part of a leaf. The upper side and underside of the leaf consist of a single layer of cells (pink in the drawing). This tissue is called the **epidermis**. The epidermal tissue protects the plant from outside influences.

fig. 5 Cross-section of a leaf.



There are **stomata** between the epidermal cells. A stoma (plural: stomata) consists of two long cells with a small opening in between. Plants take in carbon dioxide from the air and release oxygen through the stomata.

If the stoma is open, water evaporates from the leaf. That is why many plants have most stomata on the undersides of their leaves: the water doesn't evaporate so easily from the underside of the leaf. If a plant is in danger of losing too much water through evaporation nevertheless, the stomata close up.

ANNUAL RINGS

One tissue that is found in a tree trunk is the **cambium**. This is a layer of cells just beneath the bark. The cambium forms new wood on the inside, facing the centre of the trunk. So the cambium stays just underneath the bark.

Trees grow fast in the spring. The new wood cells formed then are large and pale-coloured. The tree doesn't grow so fast in summer. The new wood cells formed in summer are smaller and the layer of cells is darker coloured. The tree does not grow during autumn and winter.

So each year a new layer of wood is formed that consists of a light part and a dark part. The wood that a tree adds in a single year is called an **annual ring**. You can see the annual rings clearly in a cross-section of a tree trunk (see figure 6).

The oldest wood is in the middle of the trunk. If a tree has been sawn through just above ground level, you can find out how old the tree was. You do that by counting the annual rings.

fig. 6 Annual rings.



KNOWLEDGE

1

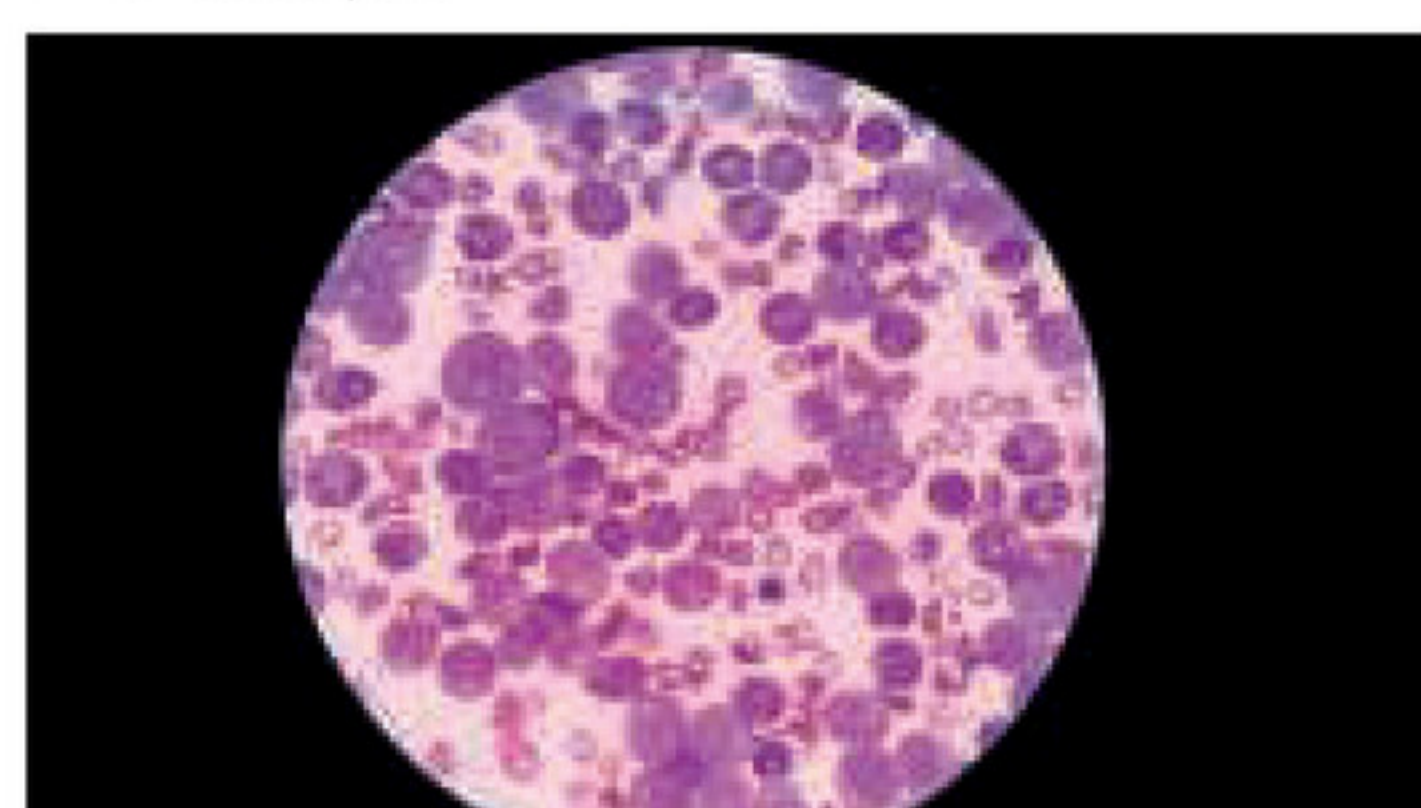
Figure 7 shows blood under the microscope.

a What can you see in this figure?

- ☐ A cells
- ☐ B a tissue
- ☐ C extracellular material

b Explain why cells look different under a microscope than in reality.

fig. 7 Blood seen through a microscope.



2

An organ consists of various tissues.

a What is a tissue?

b Give three examples of tissues in humans.

c Give two examples of tissues in plants.

3

Figure 8 shows part of a plant.

- What is this part called?
- What is the function of this part of a plant?
- In which tissue in a plant can you find this part?

4

Figure 9 shows a cross-section of a tree trunk.

- What is the name of the tissue labelled with the letter P?
- Which letter points to older wood? *P / Q / R*
- How do you recognise an annual ring in the cross-section?

fig. 8



fig 9 Cross-section of a tree trunk.



5



Summary

Make a summary of this Basics section. Do that by answering the questions.

- What do organisms consist of?
- What is a tissue?
- Give examples of tissues in humans and plants.
- What is the function of the epidermis and the stomata in the epidermis?
- What is cambium and what is the function of cambium?
- What is an annual ring and how do you recognise an annual ring in the cross-section of a tree trunk?

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INSIGHT

6

An organism consists of cells, organ systems, organs and tissues.

a Put these parts in the correct sequence from large to small.

1

2

3

4

b Figure 10 shows a cross-section of the stem of a sunflower. Which parts can you *not* see in the figure?

- ☐ A cells
- ☐ B organ systems
- ☐ C organs
- ☐ D tissues

fig. 10 Cross-section of the stem of a sunflower.

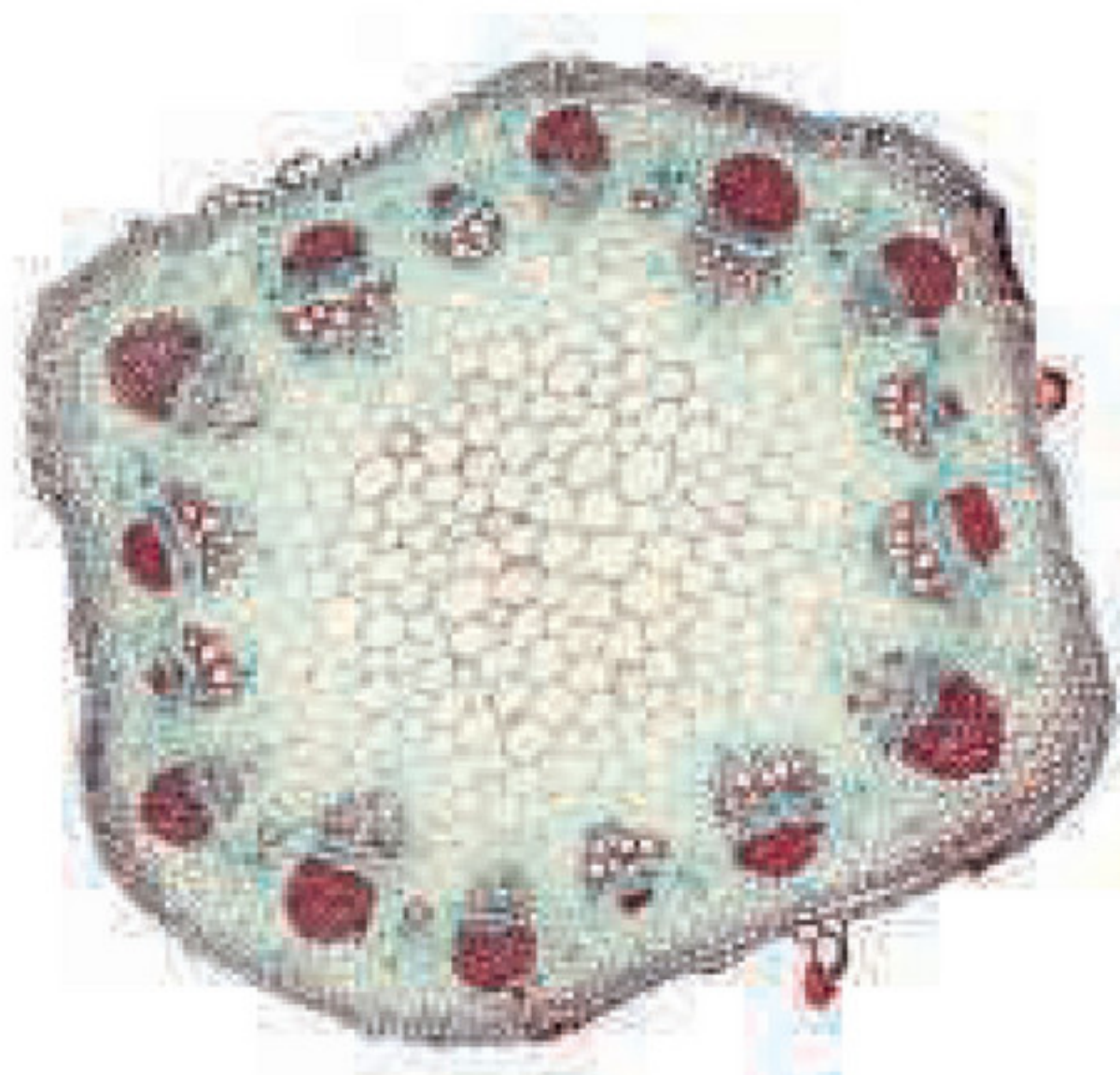
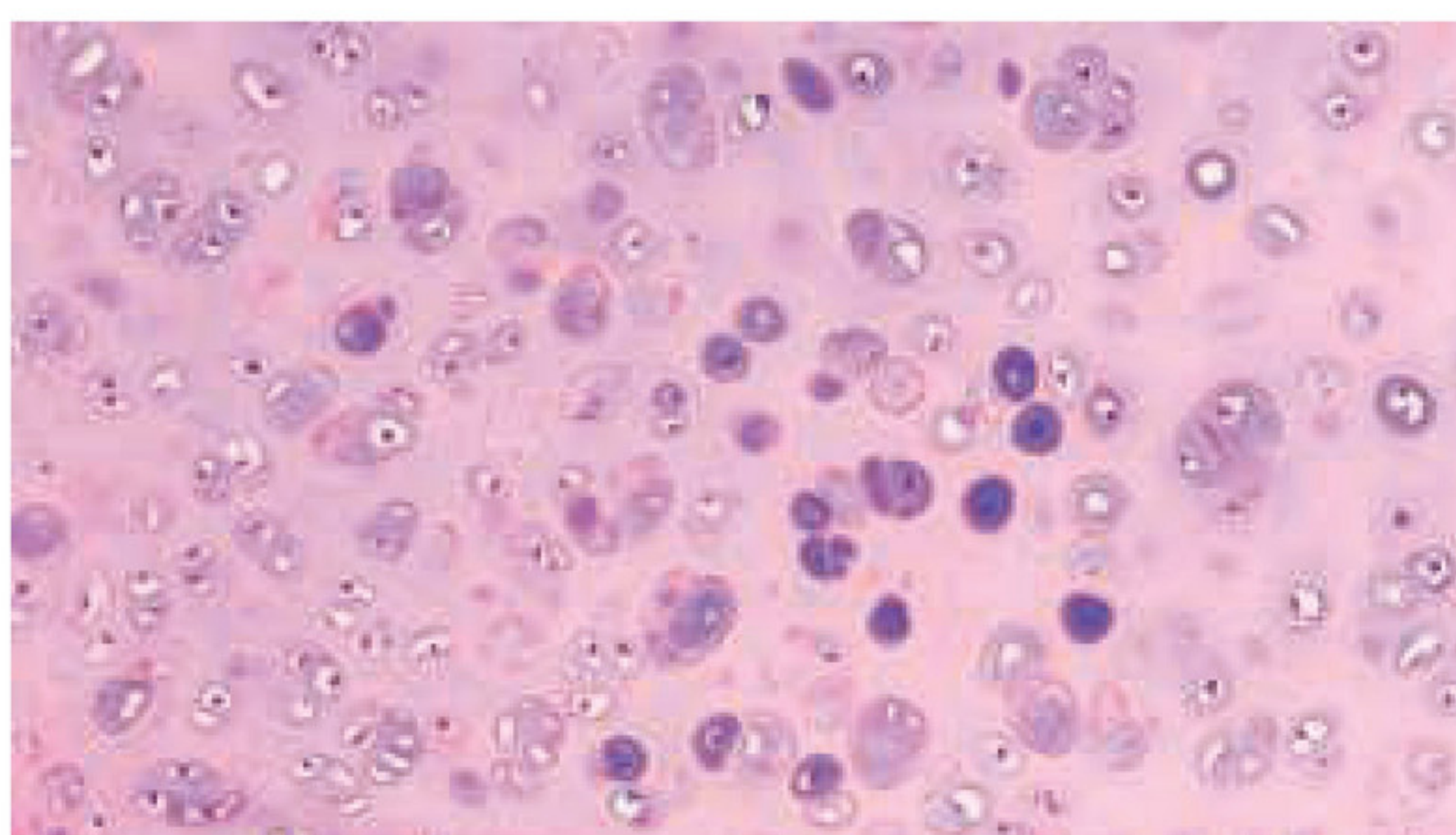


fig. 11 Cartilage.



7

You can fold your ear over. It contains cartilage tissue (see figure 11). The humerus (the bone in your upper arm) contains bone tissue, which you can't fold over. Why is cartilage tissue bendy but bone tissue isn't?

8

If someone has severe burns, skin grafts are often carried out. This is an example of tissue donation.

The skin is an organ. Explain why this is tissue donation and not organ donation.

+ 9

Plants breathe through stomata and they need a lot of them. When the stomata are open, the plant soon loses a lot of water through evaporation.

- a** Why do there have to be enough epidermal cells between the stomata in the epidermal tissue?
- b** Why should plants not make too few stomata, but not make too many stomata either?

HOW IT FITS TOGETHER science

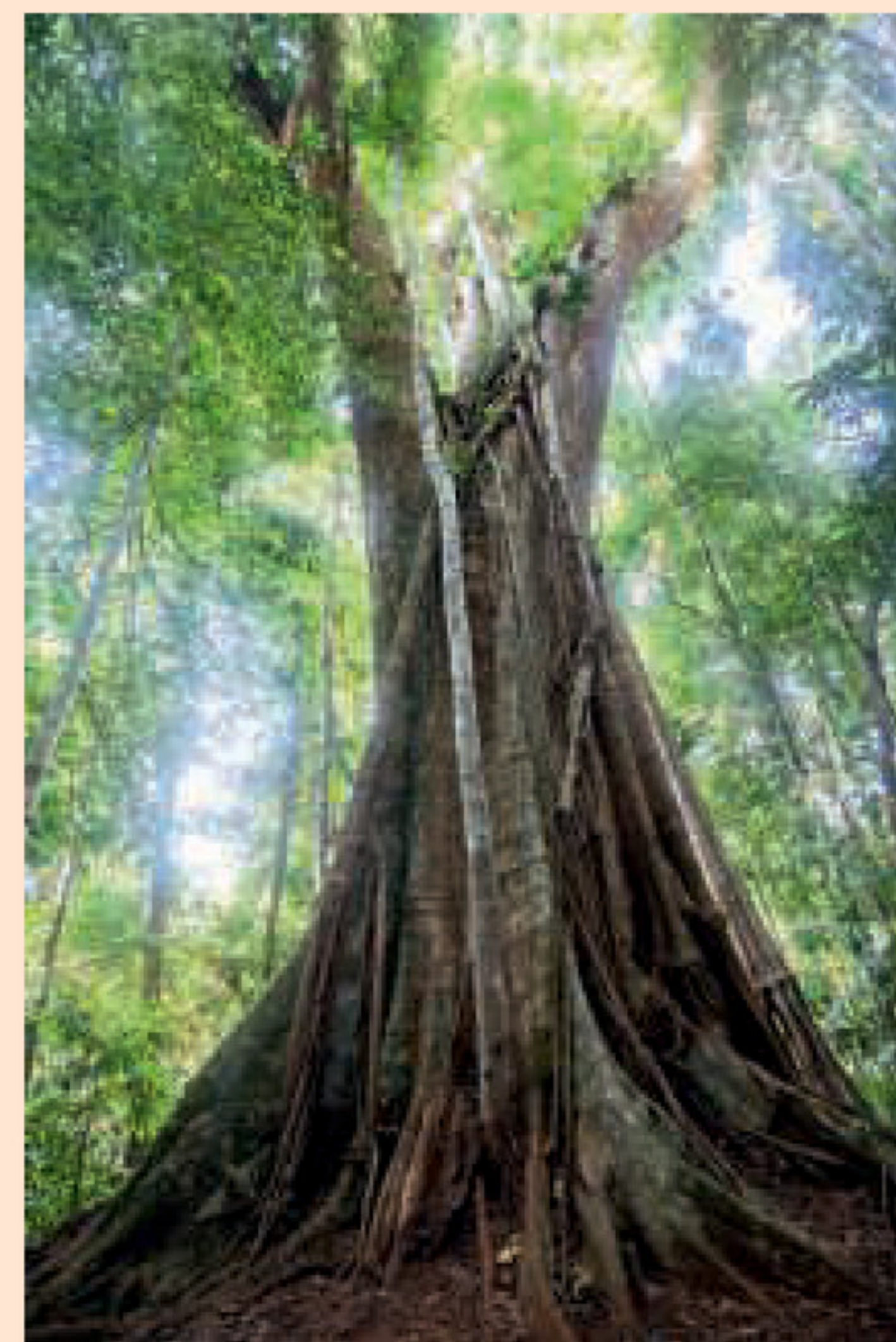
WHERE ARE THE LITTLE ONES?

Researchers from Wageningen University studied a jungle in Thailand to work out why there were a lot of large afzelia trees but no small trees. They looked at the annual rings in the wood of these trees. Thailand doesn't have a winter but it does have a dry season in which trees lose their leaves. This creates annual rings in the trees.

To avoid having to fell the trees, the researchers used a drill with a hollow bit to get cores of wood from living trees. They used the cores to determine the age of the trees. They also used the distance between the annual rings to calculate how fast the trees grew in the past. They discovered that the trees were mainly either about 160 years old or about 60 years old; there were no younger afzelias. They could also tell that the afzelia trees grew fastest when they were young.

The researchers suspect that the forest was hit by hurricanes twice in the past, knocking a lot of trees down. That created open spaces in which young afzelias could grow.

fig. 12 An afzelia tree.



10

Read the text 'Where are the little ones?'

a Wood gives a plant rigidity.

Which tissue provides rigidity in humans?

b By comparing annual rings in a tree against one another, you can find out more about the conditions that the tree was growing in. If the conditions were good, the annual ring is broader. If the conditions were not good, the annual ring is narrower. Explain why.

c The researchers can see from the annual rings that the afzelia trees grew fastest when they were young.

They could see this because the annual rings were *broad / narrow on the outside / in the middle* of the tree trunk.

d In Thailand, trees have annual rings because they lose their leaves in the dry season. Explain why no new wood is made in the dry season.

e In the Netherlands, the annual rings in trees have a light-coloured layer and a dark layer. The wood cells in the light layer are large and the wood cells in the darker layer are smaller. The wood in an annual ring of an afzelia in Thailand has the same colour everywhere and the wood cells are all the same size.

What does this say about the speed of growth during the growing period for trees in Thailand?

 Go to the *Flash cards* and the *Test yourself* section.

4 Cells

LEARNING OBJECTIVES

2.4.7 You can name parts of animal cells with their features and functions.

► Practical activities 10, 11, 12 and 13

2.4.8 You can name parts of plant cells with their features and functions.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	2.4.7	2.4.8	2.2.3*
Remembering	1, 2	2, 4	
Understanding	5	3, 5	
Using	6	6, 7	
Analysing	9, 10ab	8, 9, 10c	10c

* You can find this learning objective in another Basics section.

Some cells are shaped like balls. Others look like boxes or stars. Even if their shapes are different, cells largely have the same structure.

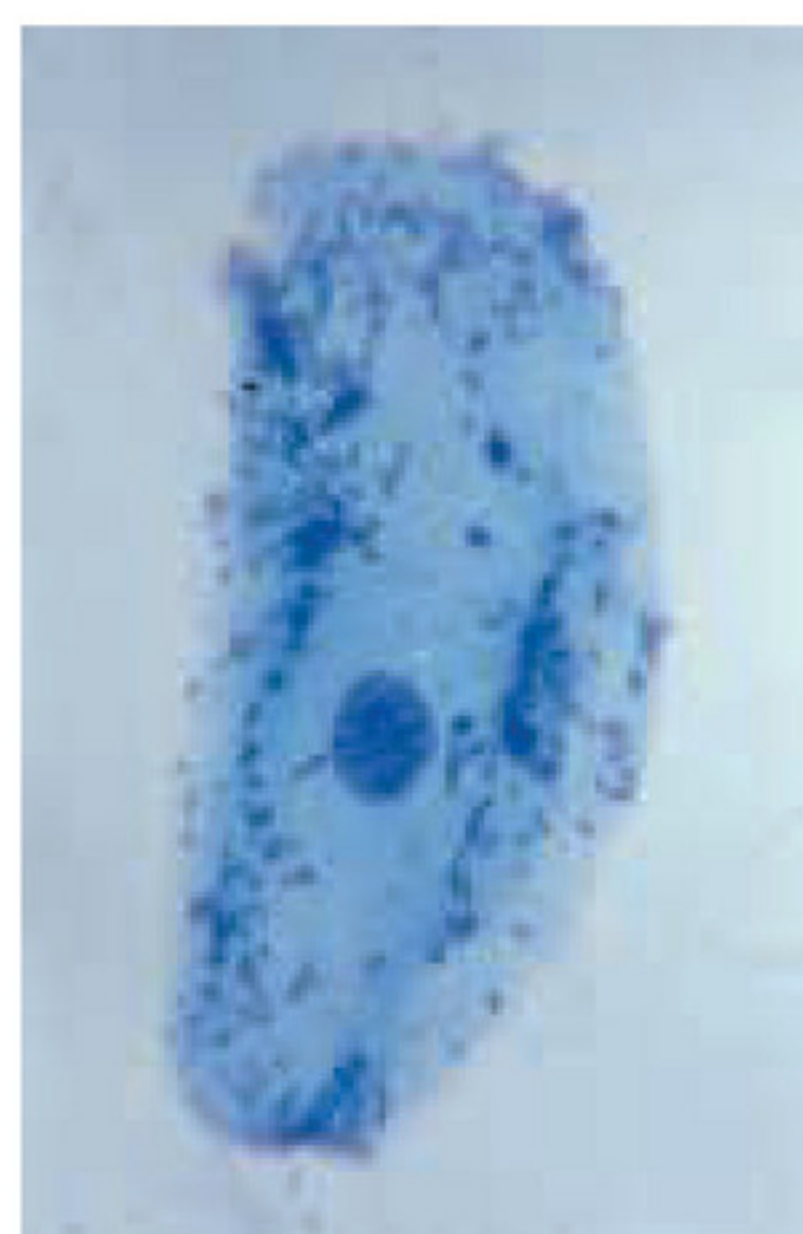
ANIMAL CELLS

Animals (including humans) are made up of animal cells. Animal cells contain a thick fluid known as the **cytoplasm** (cell plasma). It is surrounded by a **cell membrane** (a thin skin). The cytoplasm consists of water with dissolved substances and floating particles. The cell membrane separates the contents of the cell from its surroundings. The membrane consists mainly of fats and proteins.

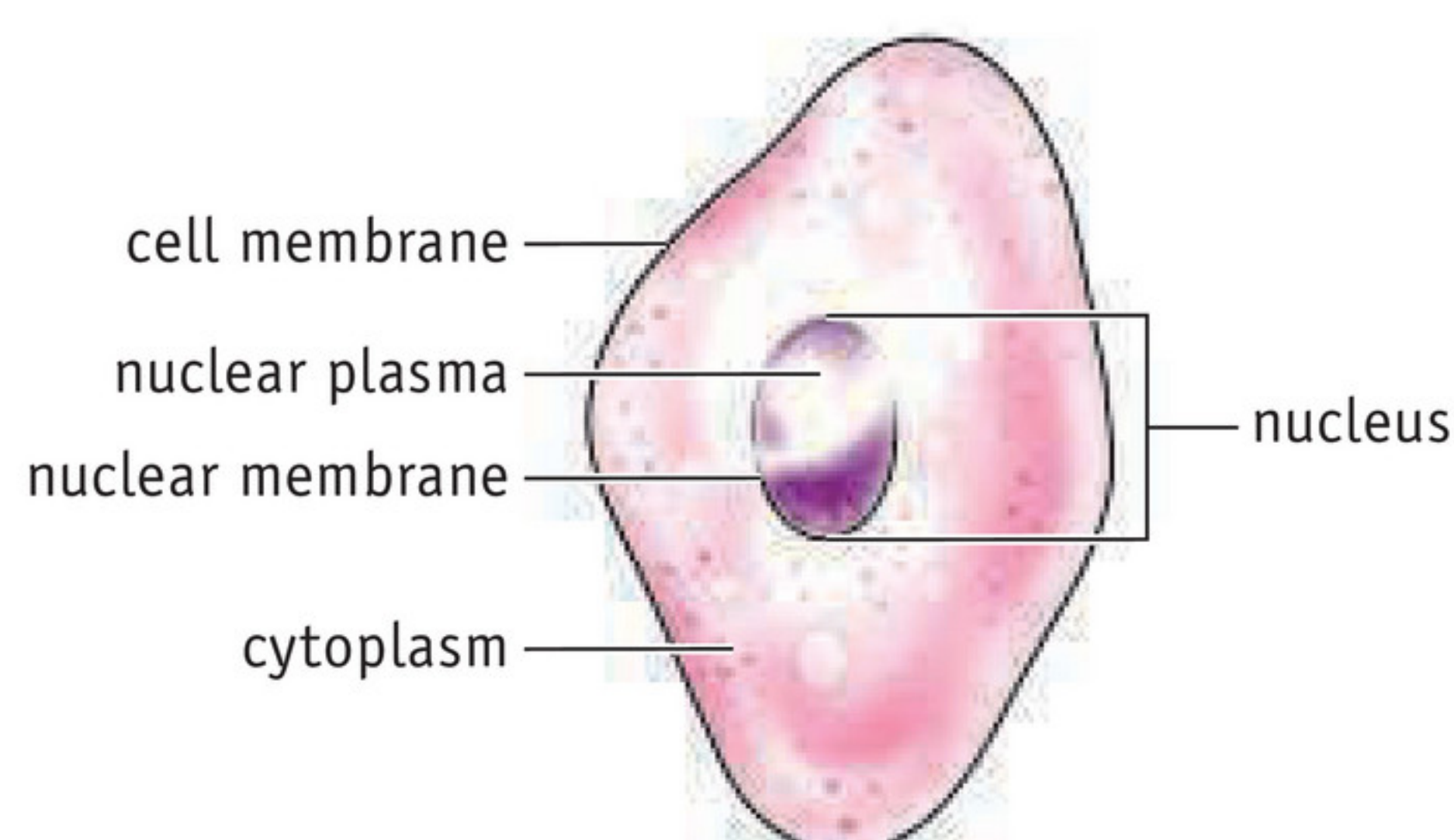
Some substances can pass through the cell membrane, for example oxygen. Other substances, such as glucose, can't. The cell can bring in substances that it needs with the help of certain proteins in the cell membrane. These proteins can take up useful substances from the surroundings and release them again on the inside of the cell. They also take waste products from the cell outside to the surroundings.

The **nucleus** is found in the cytoplasm. The nucleus manages the cell: it is the cell's control centre. The nucleus consists of **nuclear plasma** and is surrounded by a membrane: the **nuclear membrane** (see figure 1).

fig. 1 An animal cell.



1 photograph of a cell (cheek lining cell, 260× magnification)

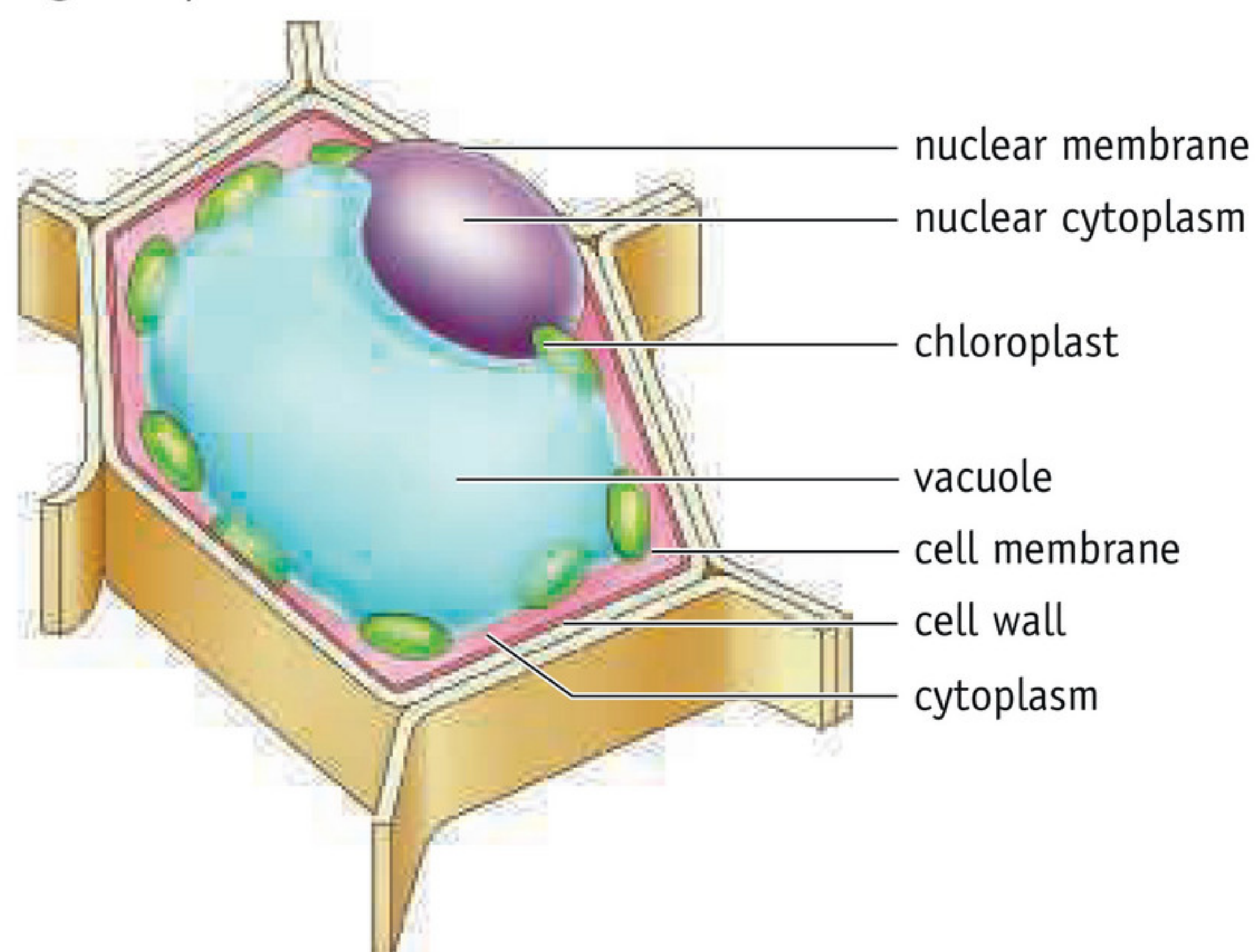


2 schematic drawing of a cell

PLANT CELLS

All plant cells have the parts that animal cells have: cytoplasm, cell membrane and nucleus. But plant cells also have parts that animal cells don't have (see figure 2).

fig. 2 A plant cell.



Plant cells create a strong layer to surround the cell, called the **cell wall**. Cell walls make everything firm. The cell wall is not part of the cell, it goes around the cell. So it is extracellular material.

Most plant cells have a large **vacuole** in the middle of the cell. A vacuole is a kind of sac filled with liquid (water with dissolved substances). The vacuole has several functions, such as storing substances and giving the cell its rigidity.

Plastids can be found in the cytoplasm of plant cells. These are granules with special functions. There are different kinds of plastids, such as:

- chloroplasts
- chromoplasts
- amyloplasts

Chloroplasts are found in the green parts of a plant (see figures 2 and 3). Photosynthesis takes place in the chloroplasts. The chloroplasts also give plants their green colour.

Chromoplasts are found in the cells of flowers and fruits that are yellow, orange or red (see figure 4). Chromoplasts give the flowers and fruits their colour.

Amyloplasts are starch grains that are found in the cells of potatoes, for instance (see figure 5). Amyloplasts store starch. The granules don't have a colour; a purple stain has been added in figure 5 to let you see the granules better.

Plastids can change from one type to another. When a tomato ripens, the colour changes from green to red. The green chloroplasts then change into red chromoplasts.

fig. 3 Chloroplasts in the cells of waterweed.



fig. 4 Chromoplasts in the cells of a tomato.



fig. 5 Amyloplasts in the cells of a potato.



CELL ORGANELLES

The parts of a cell that have their own specific functions are called **cell organelles**.

Examples of cell organelles are the nucleus, the vacuole and the plastids. Animal and plant cells contain many other organelles as well.

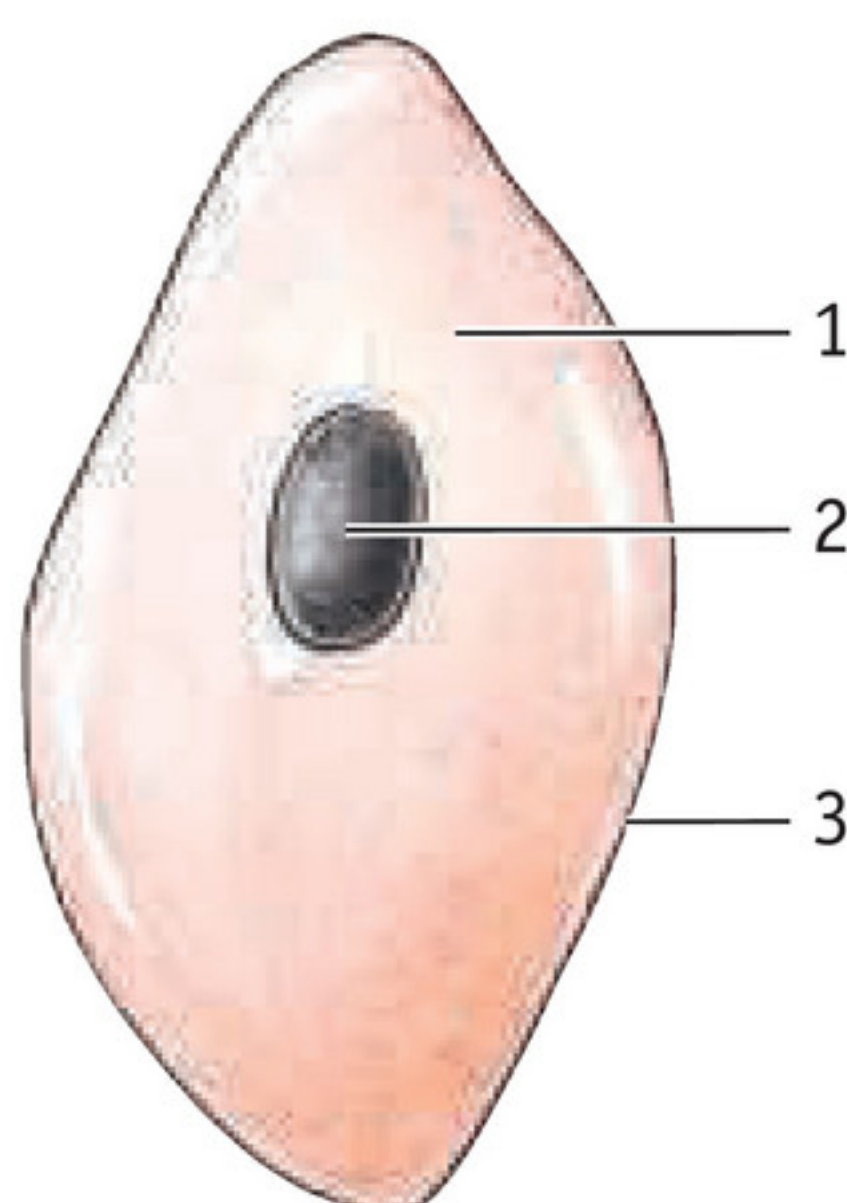
KNOWLEDGE

1

Study figure 6.

- a** This is *an animal* / *a plant* cell.
- b** Which number label is the cytoplasm? 1 / 2 / 3
- c** What is the function of part number 2?

fig. 6



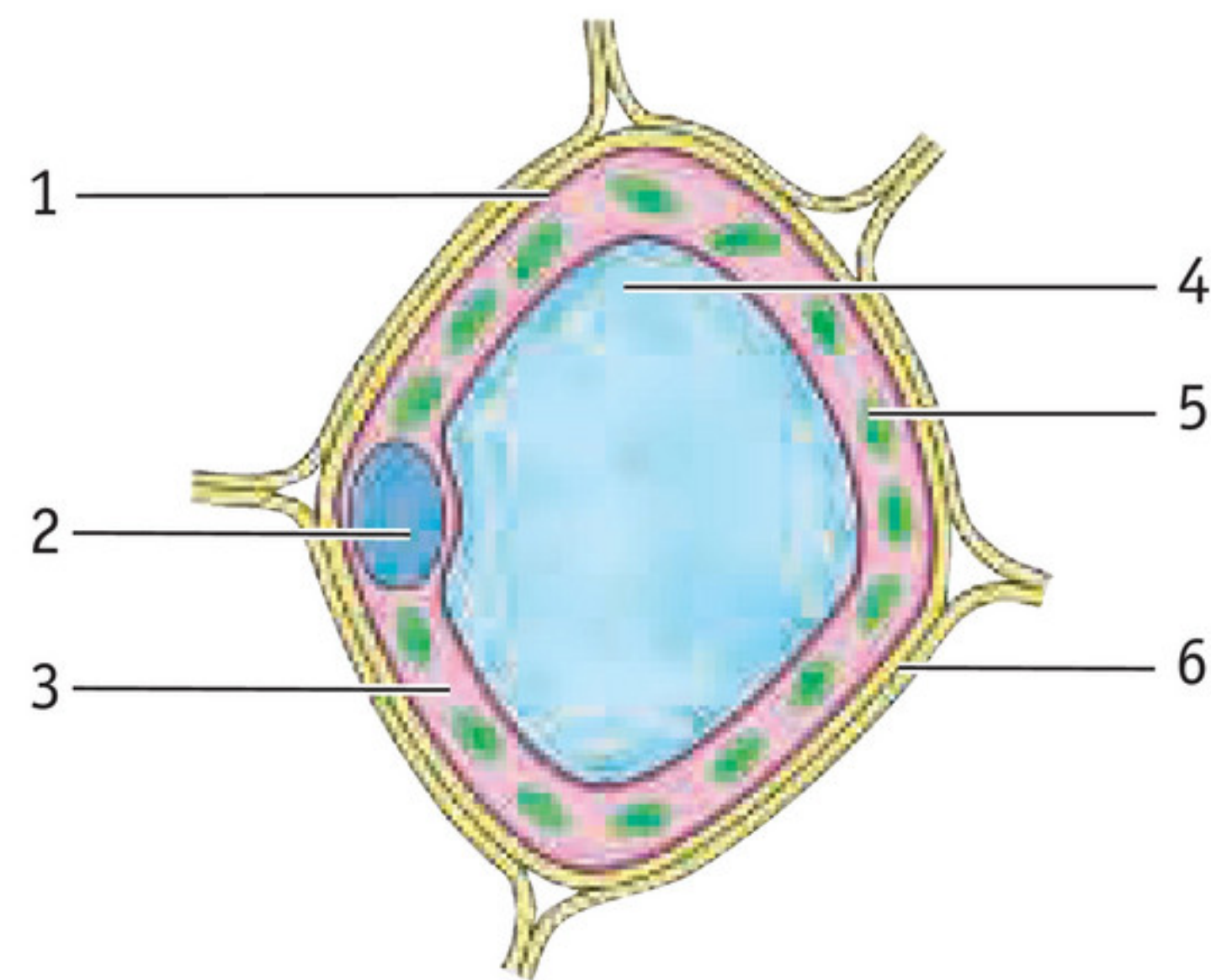
2

Certain proteins in the cell membrane have a role in transporting substances. Explain how.

3

- Figure 7 shows a schematic drawing of a plant cell.
- a Which number label is the extracellular material? 1 / 2 / 3 / 4 / 5 / 6
 - b Which part is labelled number 2?
 - c What is the function of part number 5?
 - d Which number labels the part that gives rigidity and stores substances?
1 / 2 / 3 / 4 / 5 / 6

fig. 7 A plant cell (schematic).



4

- a What are cell organelles?
- b Which plastids give flowers and fruits their yellow, orange or red colour?
chloroplasts / chromoplasts / amyloplasts

5



Summary
Make a summary of this Basics section. Do it by completing the table.

Part	Found in plant cells	Found in animal cells	Function
Chloroplast			
Nucleus			
Cell membrane			
Cell wall			
Cytoplasm			
Large vacuole			

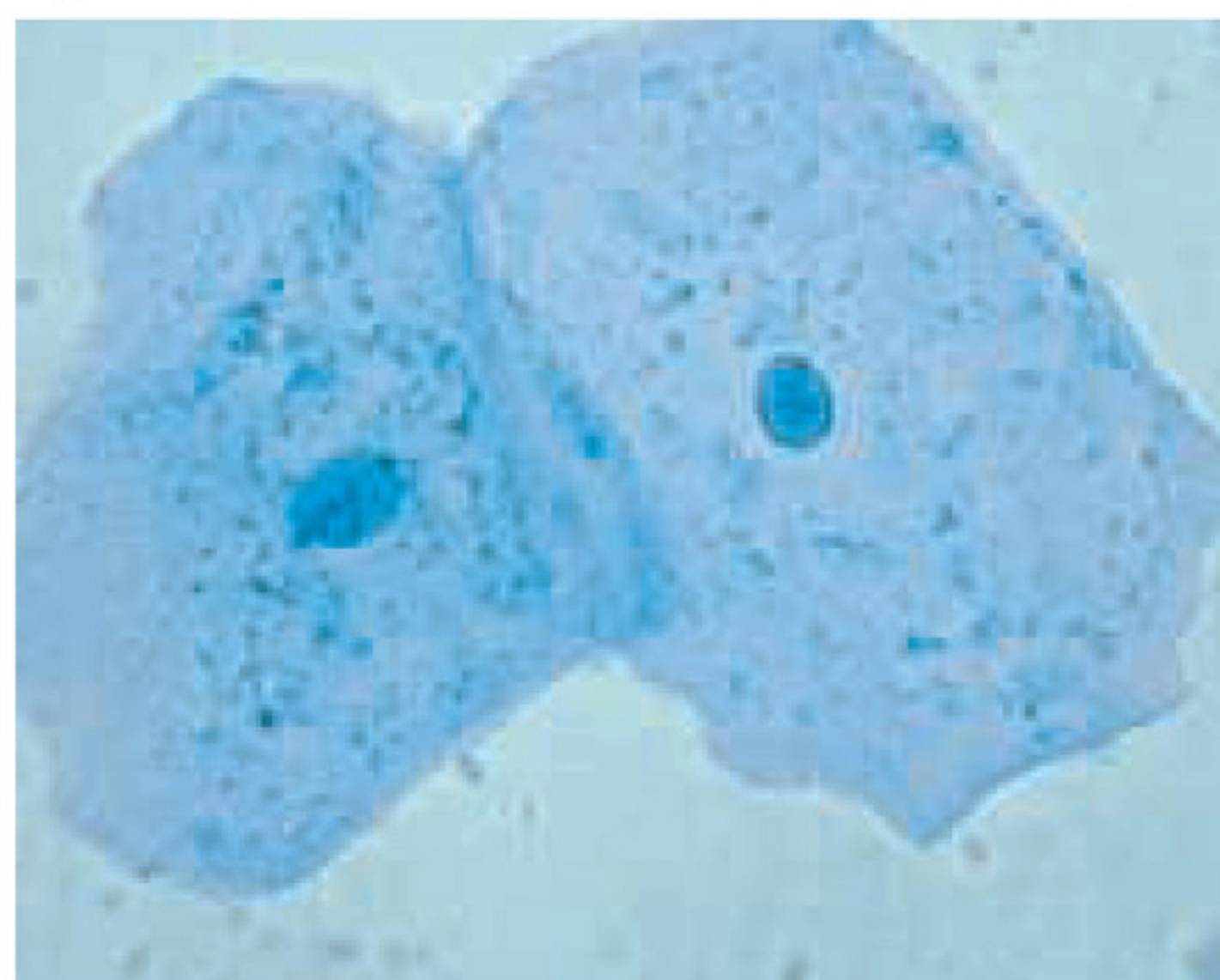
INSIGHT

6

Figure 8 shows three different cell types.

- a** Which cell type or types are found in a cat (see figure 9)?
- b** Which cell type or types are found in a potato plant (see figure 10)?

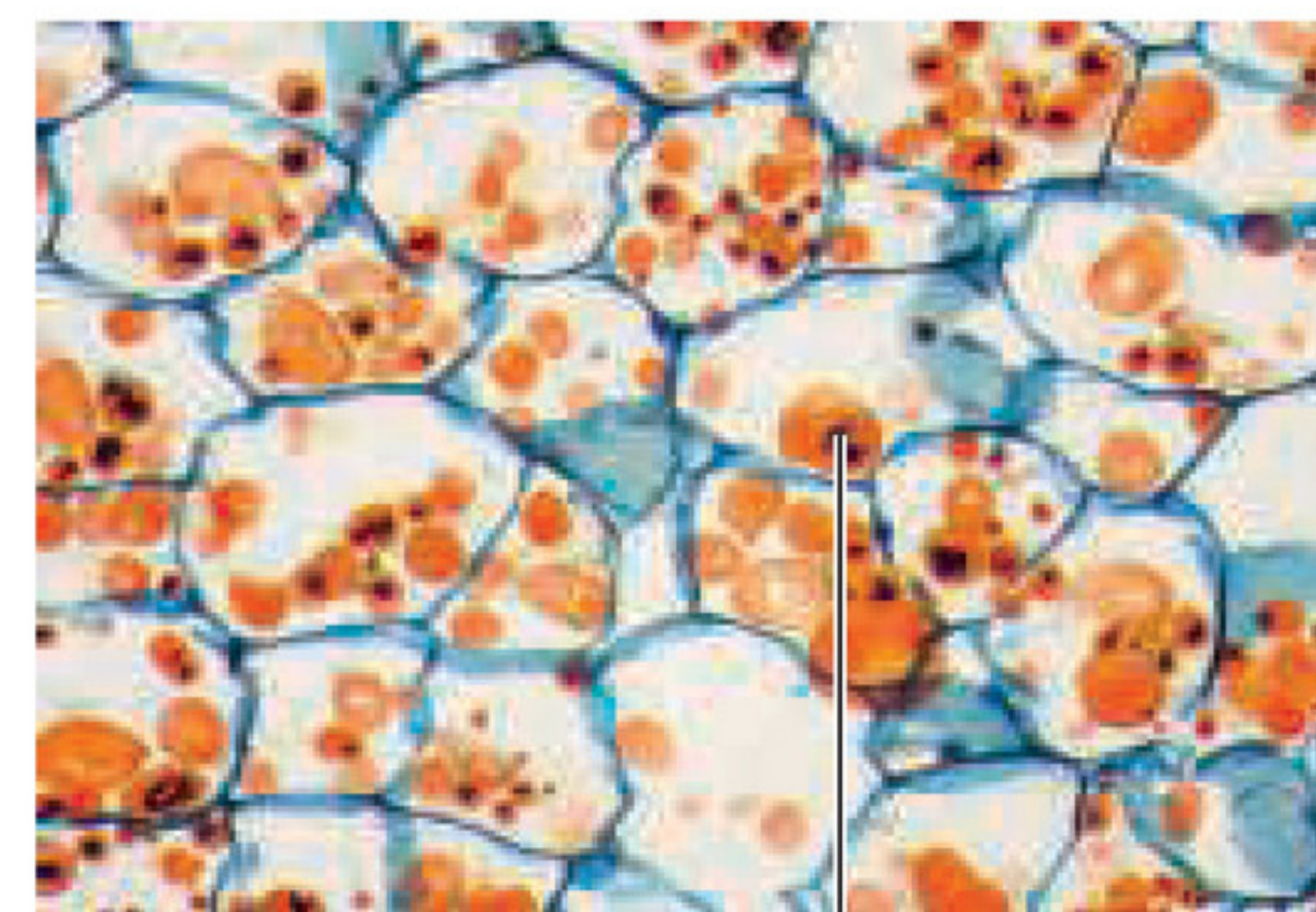
fig. 8 Different cells.



1



2



3

starch grain (amyloplast)

fig. 9 A cat.



fig. 10 A potato plant.



7

Figure 11 shows one green pepper and two red peppers. Explain the difference between the peppers' colours.

+ 8

Anthocyanins are purplish-red pigments that can sometimes be found in the vacuoles of plant cells, for example in red cabbage (see figure 12).

- a** Explain why anthocyanins are not plastids.
- b** Many plants make extra anthocyanins in periods of very strong light. Biologists think they do this for protection against damage from too much light. The anthocyanins function a bit like sunglasses for the leaf.
What effect does forming extra anthocyanins have on photosynthesis?

fig. 11 Green and red peppers.**fig. 12** Red cabbage.**+ 9**

Cells are all very small but they still differ in size. In the smaller cells, the cell membrane surface area is large in proportion to the cell's volume, and vice versa for larger cells. What is the advantage of a relatively large surface area?

HOW IT FITS TOGETHER science

SALTY POPCORN?

Climate change is making sea levels rise all over the world. Farmland is becoming more saline (saltier) due to flooding with seawater or because of seawater getting into the land underground.

Most agricultural crops don't grow in saline soil. The plants die if too much salt gets into their cells. But there are exceptions. Experiments are carried out in fields to see which crops can withstand salt. Two special maize varieties have been found, for example, that do grow in saline soil. One of the maize varieties keeps the salt 'outside the door' with microscopic pumps. The other variety survives by storing the salt in vacuoles, in particular in the vacuoles of the root cells. These plants grow slowly but they can survive even in very saline soil.

fig. 13 A maize cob.**10**

Read the text 'Salty popcorn?'

- a** One of the maize varieties keeps the salt 'outside the door' with microscopic pumps. Which part of the cell is the 'door' and what are the 'pumps'?
- b** Popcorn is made from sweetcorn, the seeds of a maize plant. Maize plants that store salt in the vacuoles of their cells become 'saltier'. Explain why the popcorn from these maize plants won't taste salty even so.
- c** The fact that more and more farmland is becoming saline and most agricultural crops can't grow in this soil could be a problem for humans. Explain why this could become a problem.

 Go to the *Flash cards* and the *Test yourself* section.

5

The nucleus

LEARNING OBJECTIVES

- 2.5.9 You can name the features of chromosomes.
- 2.5.10 You can describe the structure and function of DNA.
- Practical activity 14

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	2.5.9	2.5.10
Remembering	1	2, 3a
Understanding	5, 6	3b, 4, 6, 11acd
Using	7	8, 9, 11b
Analysing		10

A cell is managed by a control centre, the nucleus. The nucleus contains all the information needed to do that. You inherit this information from your parents.

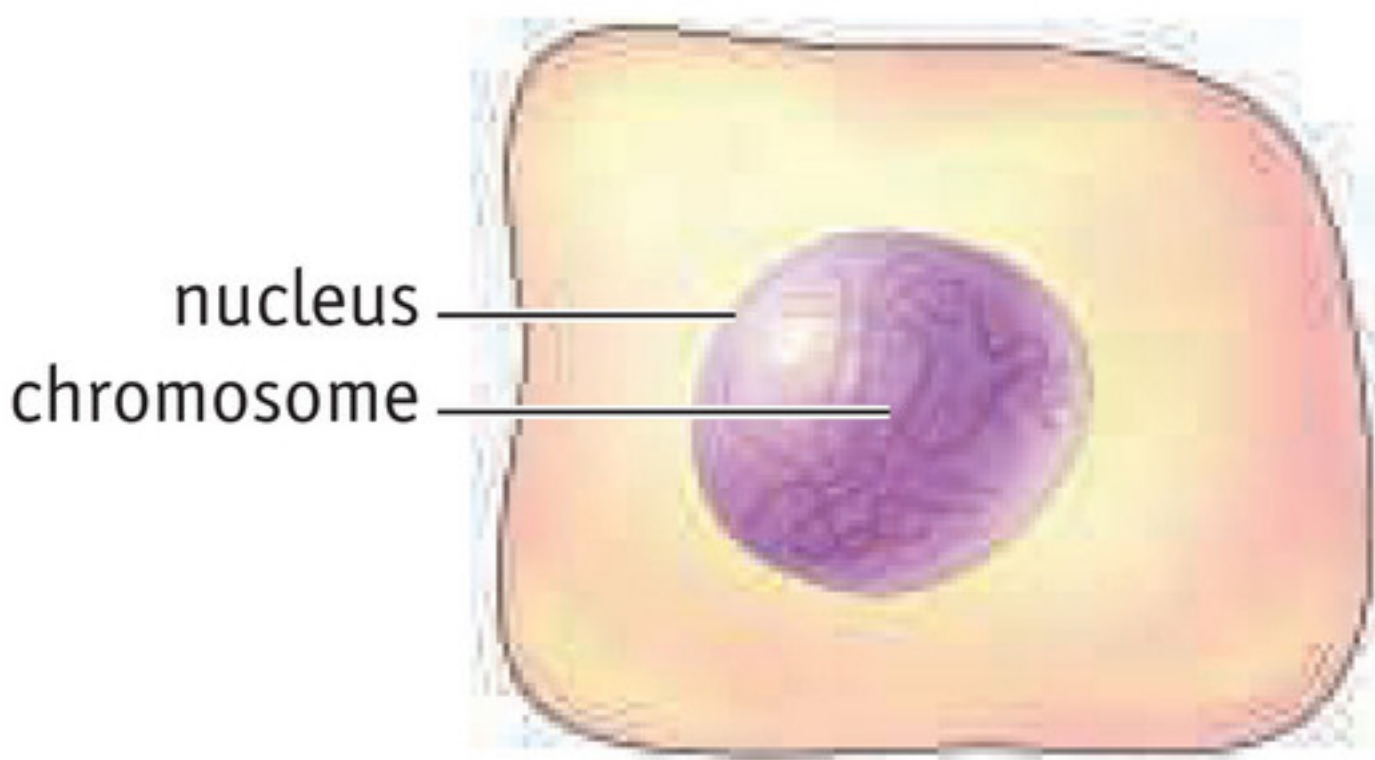
CHROMOSOMES

Every cell nucleus in your body contains long, thin threads known as **chromosomes**. The chromosomes control what happens in the cell. They are all tangled together in the nucleus (see figure 1.2). You can't see the chromosomes under a microscope except when a cell is dividing. Then the chromosomes become shorter and thicker, and they become visible too (see figure 1.3).

fig. 1 The nucleus contains chromosomes.



1 a microscope photo of the nucleus in a cell that is not dividing



2 a schematic drawing of the nucleus of a cell that is not dividing



3 a microscope photo of a nucleus during cell division

The cells that make up your body are called **body cells**. Some examples of body cells are skin cells, liver cells and muscle cells. There are 46 chromosomes in the nucleus of a human body cell. Other organisms have a different number of chromosomes in their body cells (see table 1).

Table 1 The number of chromosomes in various organisms.

Organism	Number of chromosomes per cell
Fly	12
Onion	16
Tomato	24
Cat	38
Human	46
Chimpanzee	48
Cow	60
Horse	64
Dog	78
Hedgehog	88

THE STRUCTURE OF DNA

Chromosomes consist largely of the substance **DNA** (see figure 2). You can picture DNA as a spiral staircase with more than a million steps. Each step of the spiral staircase consists of two pieces that fit together precisely (see figure 3.1). These pieces are called **bases**. There are four different bases. They are referred to by the letters A, T, C and G. The four bases can form pairs. A and T always form a pair and so do C and G. Each pair (an A–T or C–G) is called a **base pair** (see figure 3.2).

fig. 2 A chromosome consists largely of DNA.

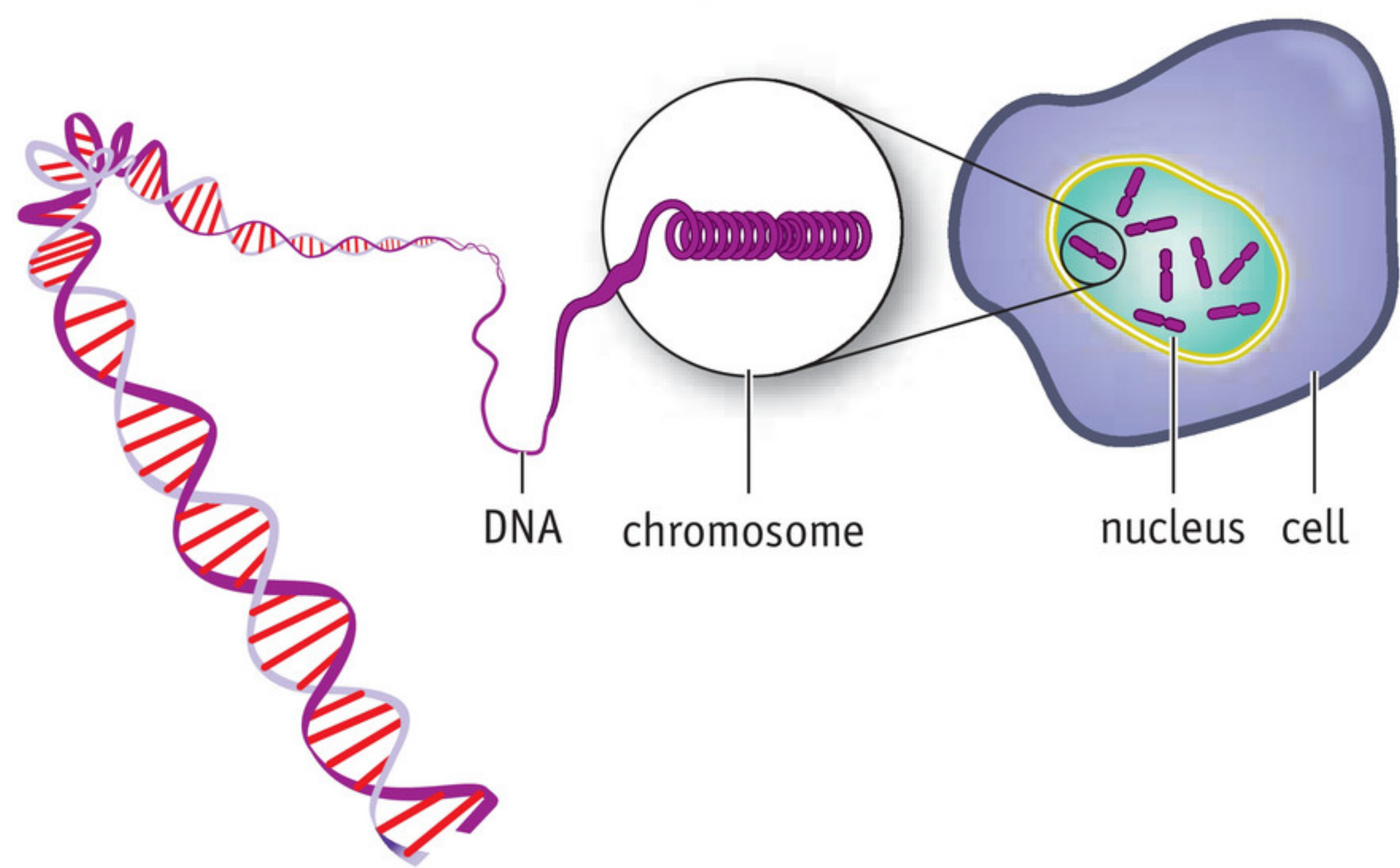
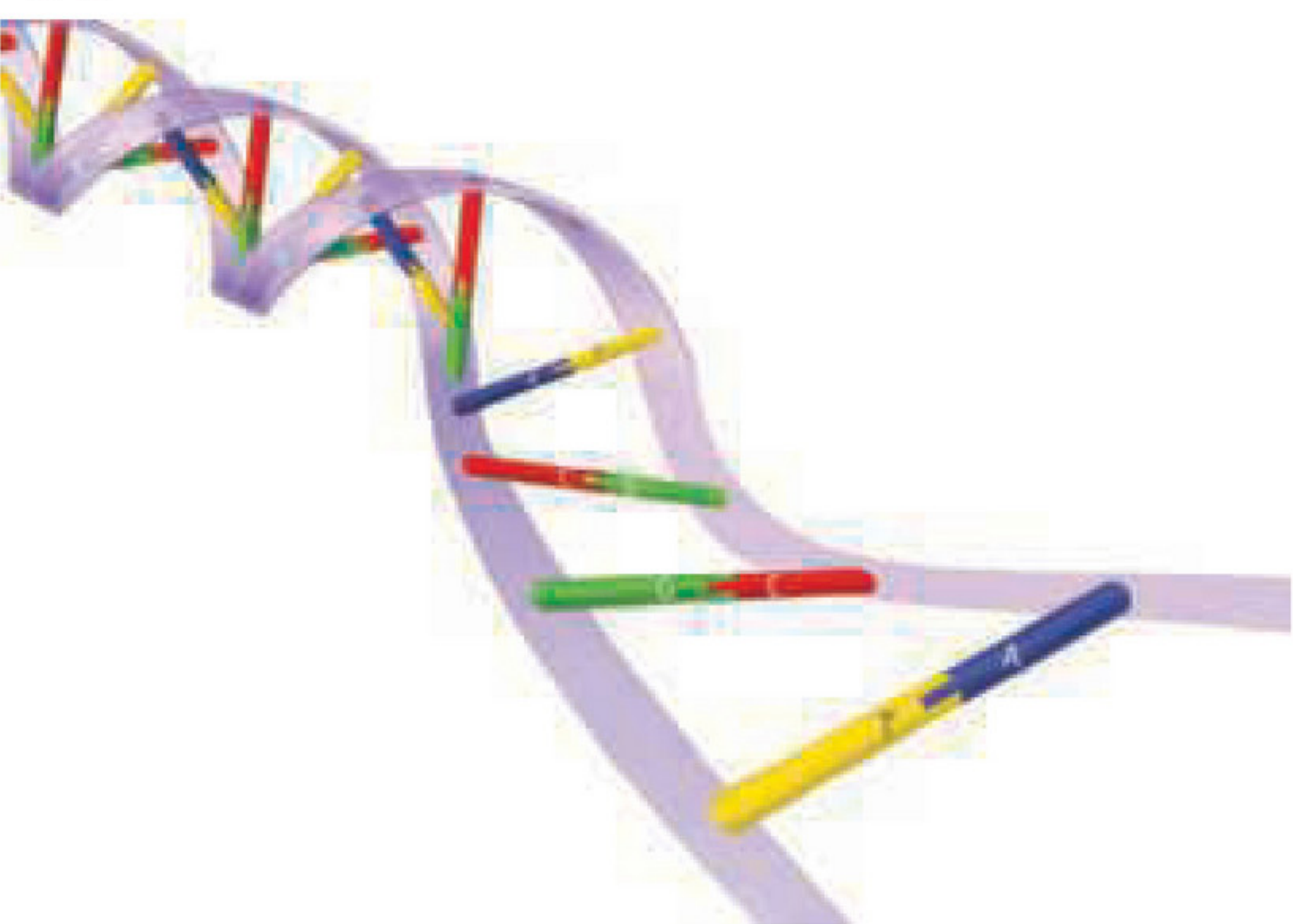
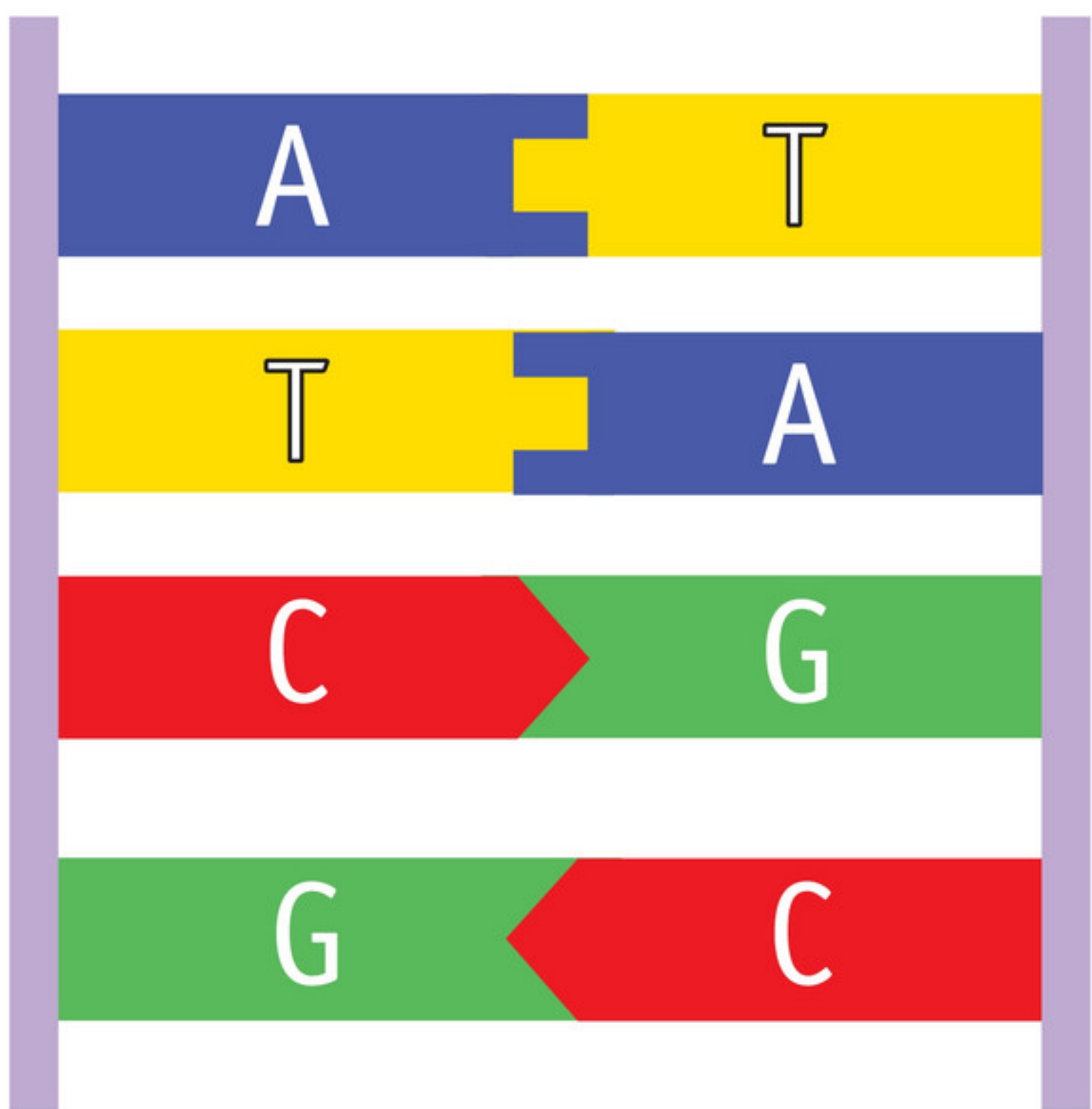


fig. 3 The structure of DNA.



1 A DNA molecule looks like a long spiral staircase.



2 A base pair consists of A plus T or C plus G.

THE FUNCTION OF DNA

An awful lot of information is stored in a DNA chain. The DNA contains information for all your physical characteristics, for example the colour of your eyes. The coloured part of your eyes is called the iris. Cells in your iris contain pigments. The DNA determines which pigments those are (for example brown or blue). The DNA determines which pigments the cells in your iris make.

That information is stored in the DNA because of the order in which the base pairs A–T and C–G appear. That works rather like writing does. The Dutch alphabet consists of 26 letters. Those letters can make lots of different combinations. Each combination has a different meaning. For example, ‘listen’ means something different to ‘silent’ although the letters are the same. In DNA, information is stored in the same way, except that it only uses four letters (the bases).

HEREDITARY CHARACTERISTICS

You inherit the information in your DNA from your parents (half from your father and half from your mother), for example the information about your eye colour. Characteristics that you inherit the information for from your parents are called **hereditary characteristics**. Other examples of hereditary characteristics are the shape of your face and whether you can make certain substances that digest your food.

The exact characteristics you get in your life are not just determined by your DNA. Your environment and your lifestyle also have an influence.

GENES

Your DNA contains information about hundreds or even thousands of characteristics. Each characteristic needs thousands of base pairs. The collection of base pairs that are needed for one or more characteristics form a **gene**. The base pairs in a gene can be next to one another but usually they are spread across the DNA of one or more chromosomes.

One gene contains the information for one or more characteristics. All the genes together contain all the information for your hereditary characteristics. So each body cell in fact contains all the genetic information for an organism. A cell only uses the genes that it needs.

KNOWLEDGE

1

You can't usually see the chromosomes in a cell under a microscope.

- a** When can you see the chromosomes?
- b** Which organelle contains the chromosomes?
- c** What is the function of chromosomes?
- d** What substance are chromosomes largely made up of?
- e** How many chromosomes have you got in a body cell?

2

The DNA in chromosomes is built up from four different bases.

- a** Which bases form pairs in the DNA?
 - ☐ A A paired with C and G with T.
 - ☐ B A paired with G and C with T.
 - ☐ C A paired with T and C with G.
- b** How is hereditary information stored in the DNA?

3

- DNA contains the information for your hereditary characteristics.
- a Who did you inherit the hereditary characteristics in the DNA from?
 - b Are all your characteristics determined by your DNA? Explain your answer.

4

- a What does a gene consist of?
- b Do muscle cells and nerve cells in a human have the same genes or different genes?
the same genes / different genes

5

- The total length of all the chromosomes in a cell is two metres.
- a Explain how they can still fit in the nucleus.
 - b Red blood cells don't have nuclei but white blood cells do.
Do you have chromosomes in your red blood cells? What about your white blood cells?

6



- Summary**
- Make a summary of this Basics section. Do that by answering the questions.
- What are body cells?
 - What are the features of chromosomes?
 - Describe the structure of DNA.
 - What is the function of DNA?
 - How are your characteristics determined?
 - What does a gene consist of?

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INSIGHT

7

A company has been selling horsemeat but labelling it as beef (which lets them make bigger profits because beef is more expensive than horsemeat). If fraud is suspected, the Netherlands Food and Consumer Product Safety Authority (NVWA) can determine whether the meat is beef from a cow or horsemeat by studying the chromosomes. Explain how you can determine whether the meat is beef or horsemeat. Use table 1 for this.

8

Here is part of the sequence of bases in one of the strands of DNA. Fill in the bases for the other strand.

A	C	G	A	C	T	C	A

9

Figure 4 shows people with certain characteristics. What characteristics are they? Is that characteristic hereditary or not?

fig. 4



1
hereditary / not hereditary



2
hereditary / not hereditary



3
hereditary / not hereditary



4
hereditary / not hereditary



5
hereditary / not hereditary

+ 10

Read the text on ‘Werner syndrome’. The information for a hereditary characteristic is stored through the order in which the base pairs appear. That information could be about how a protein should be made. Figure 6 shows part of a gene in a healthy person and the same part of that gene for a person with Werner syndrome. Compare the sequence of the bases. What causes Werner syndrome?

fig. 5

Werner syndrome

Werner syndrome is a hereditary disorder that makes people age faster than normal. Children with Werner syndrome don't have a growth spurt in puberty. Signs of old age such as going grey, hair loss and thinner skin, start appearing from about the age of 20. People with Werner syndrome live to about 50 or 55. These patients age faster because they do not make a particular protein.

DNA of a healthy person																	
C	A	T	C	A	T	C	A	T	C	A	T	C	A	T	C	A	T
G	T	A	G	T	A	G	T	A	G	T	A	G	T	A	G	T	A

DNA of a person with Werner syndrome																	
C	A	T	C	A	T	C	A	T	C	C	T	C	A	T	C	A	T
G	T	A	G	T	A	G	T	A	G	G	A	G	T	A	G	T	A

fig. 6 Part of the sequence of bases in a gene.

HOW IT FITS TOGETHER the living world

THE SAME GENES, THE SAME CHARACTER?

Identical twins Tom and Rob look so alike that other people can't tell them apart. Sometimes they abuse that fact. For example, they share one ID card for the gym because they both look the same as the photo on the cards and no one notices. At secondary school, they were put in separate classes. As a result, they had different friends and they started spending more and more time apart from one another in different surroundings.

Identical twins have the same genes. They usually grow up in the same environment too. They live in the same neighbourhood and get the same education. The only differences are the times when they are not sharing the same environment. The Dutch Twins Register has invited Tom and Rob to take part in their studies. Tom and Rob would like to do that as they want to know why they differ in some aspects of their characters even though they have the same hereditary characteristics.

fig. 7 Identical twins Tom and Rob.



11

Read the text 'The same genes, the same character'.

- a What determines whether a gene in a body cell is used or not?
- b The genes for the colour of your iris *are* / *are not* used in a cell in your liver.
- c What causes the differences between Tom's and Rob's characters? Explain your answer.
- d By studying identical twins, you can learn more about the influence of *the environment* / *hereditary characteristics*.

 Go to the *Flash cards* and the *Test yourself* section.

6 Cell division

LEARNING OBJECTIVES

2.6.11 You can describe how a cell divides.

2.6.12 You can name the features of stem cells.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	2.6.11	2.6.12	2.4.8*	2.5.10*
Remembering	1bc, 2, 3c	4a		
Understanding	1a, 3ab, 5	4bc, 5		
Using	6ab, 7a, 8a, 9b			
Analysing	6c, 7b, 8bc		9a	9c

* You can find this learning objective in another Basics section.

Your body consists of 30 trillion (30,000 billion) cells. All these cells were created starting from a single cell. Cells can divide.

NEW CELLS

Some cells remain alive for years whereas others only live for a short while. The outer layer of your skin consists of dead cells, with millions being shed every day (see figure 1). They end up in your clothes and fall onto the ground. In one year you lose roughly 3.5 kg of skin. Thanks to **cell division**, new cells are continuously being formed in your skin, so the overall number does not go down.

Cells die and are replaced by new cells in all kinds of other places in your body too. You get about a million new cells every second. If more new cells are created than old cells die, you grow.

fig. 1 Dried-out dead cells in the outermost layer of the skin.

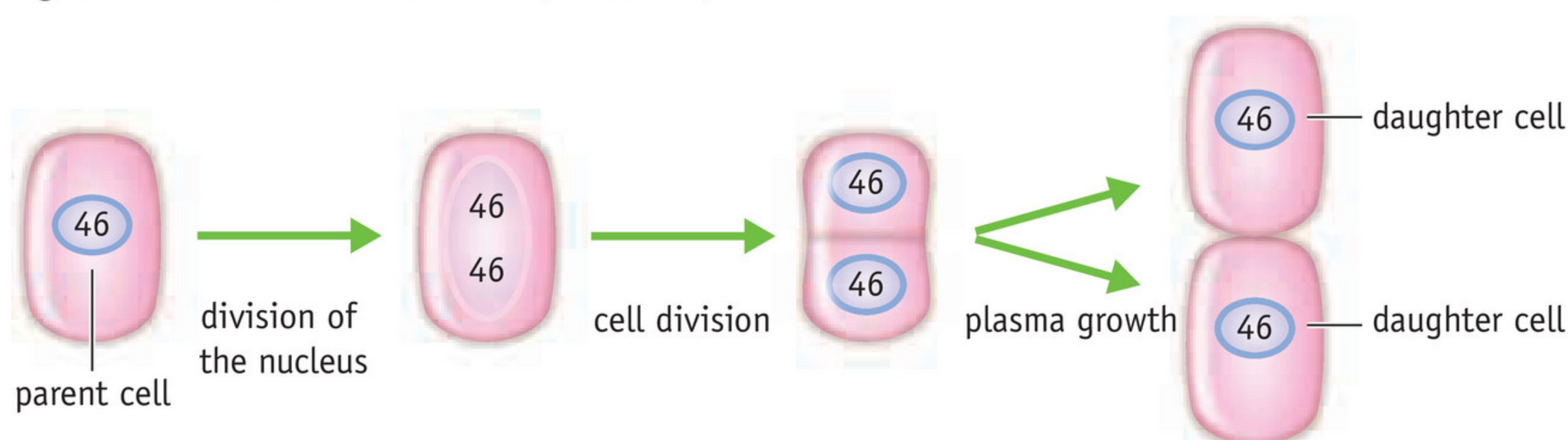


A COPY

The process for creating new cells is the same for all organisms (see figure 2). First, a copy is made of each chromosome in the nucleus. Then two nuclei are created. Each nucleus has a complete set of chromosomes. Then the cell divides.

In this way, one cell (the **parent cell**) splits into two new cells (the **daughter cells**). After the cell division, the daughter cells grow bigger as the amount of cytoplasm increases. This is called **plasma growth**.

fig. 2 The formation of new cells (schematic).



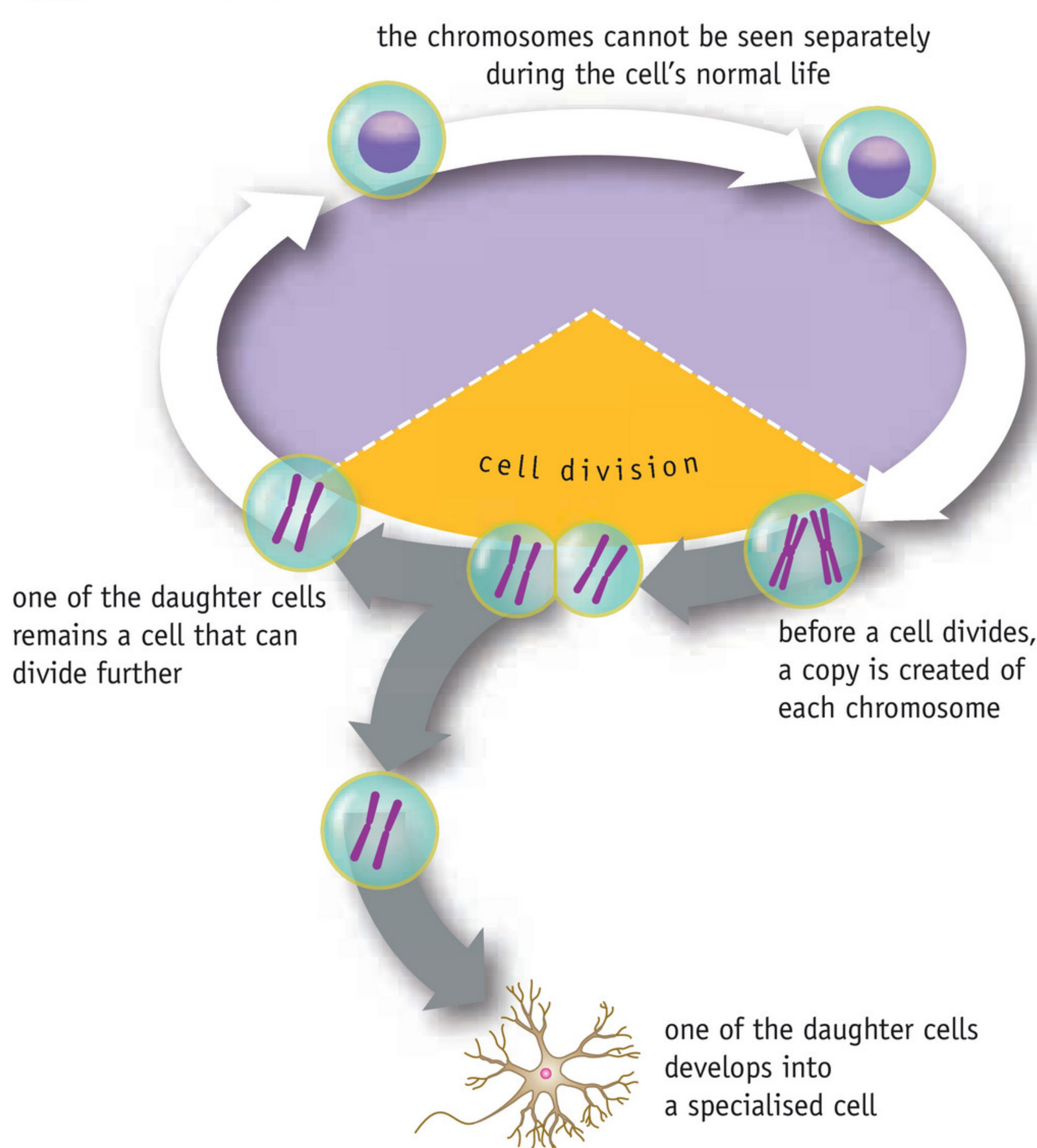
CELL CYCLE

After cell division, one of the daughter cells can develop into a **specialised cell** (a cell with a specific function). If the dividing cell is in the muscles, this might be a muscle cell. If the cell is in the skin, it will be a skin cell.

The specialised cell starts carrying out its function in the body. Usually, it won't divide further. The other daughter cell is not specialised. In the next cell division, this cell can produce another specialised cell.

The recurring process of cell division, growth and cell division again is called the **cell cycle** (see figure 3). The cell cycle is important for the growth and development of an organism.

fig. 3 The cell cycle.



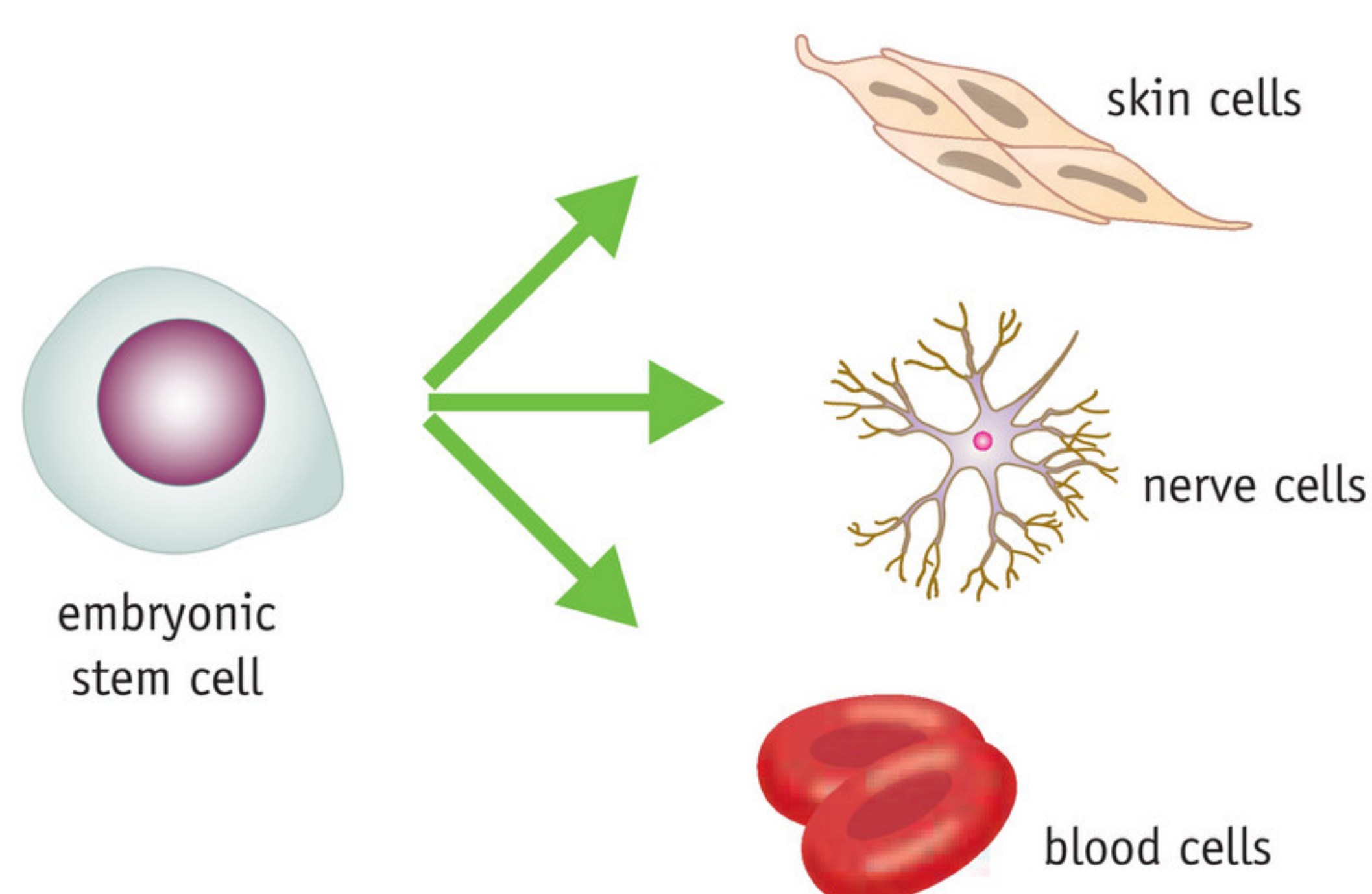
STEM CELLS

Many body cells can divide but only a limited number of times. Some cells never divide at all. There are also cells in all your body's tissues that are capable of dividing an infinite number of times. These cells are responsible for growth and for the recovery of tissues. These are the **stem cells**.

After division, most stem cells can only become specialised cells for the tissue in which they are found. For example, a stem cell in a muscle can only produce a muscle cell. But there are also stem cells that can produce several different types of cells. For example, a stem cell in the bone marrow can produce a fat cell, a bone cell or a blood cell.

All the different kinds of cells can be produced from the stem cells of an embryo (an unborn child) (see figure 4). These stem cells are called **embryonic stem cells**.

fig. 4 Different types of cells can be produced from embryonic stem cells.



KNOWLEDGE

1

- a** Does a teenager make more new cells or fewer new cells per day than an adult?
more / fewer
- b** Why does a teenager make new cells?
- c** Why does an adult make new cells?

2

Put the phases of the cell cycle in the correct order.

- The cell divides.
- The daughter cells grow due to plasma growth.
- Two nuclei are created, each with a full set of chromosomes.
- A copy is created of each chromosome.

3

Study figure 5.

- a** What kinds of cells can you see?
- ☐ A a daughter cell and a parent cell
 - ☐ B two daughter cells
 - ☐ C two parent cells
- b** After cell division, do the daughter cells have different genetic information to the parent cell or the same genetic information? *different / the same*
- c** How do the daughter cells develop further after the cell division?
- ☐ A One cell develops into a specialised cell while the other can divide again.
 - ☐ B Both cells can divide again.
 - ☐ C Both cells develop into specialised cells.

fig. 5



4

- a What are stem cells?
- b Nerve cells, muscle cells and cartilage cells develop from a certain type of stem cell. Where will you find these stem cells: in an embryo, in an adult or in both? Explain your answer.
- c What is the function of stem cells?

5



Summary

Make a summary of this Basics section. Do that by answering the questions.

- Describe the cell cycle in four steps.
- What is a parent cell?
- What happens to the daughter cells after the cell division?
- When do you grow?
- What are stem cells and what is their function?
- What is the difference between stem cells in a tissue and embryonic stem cells?

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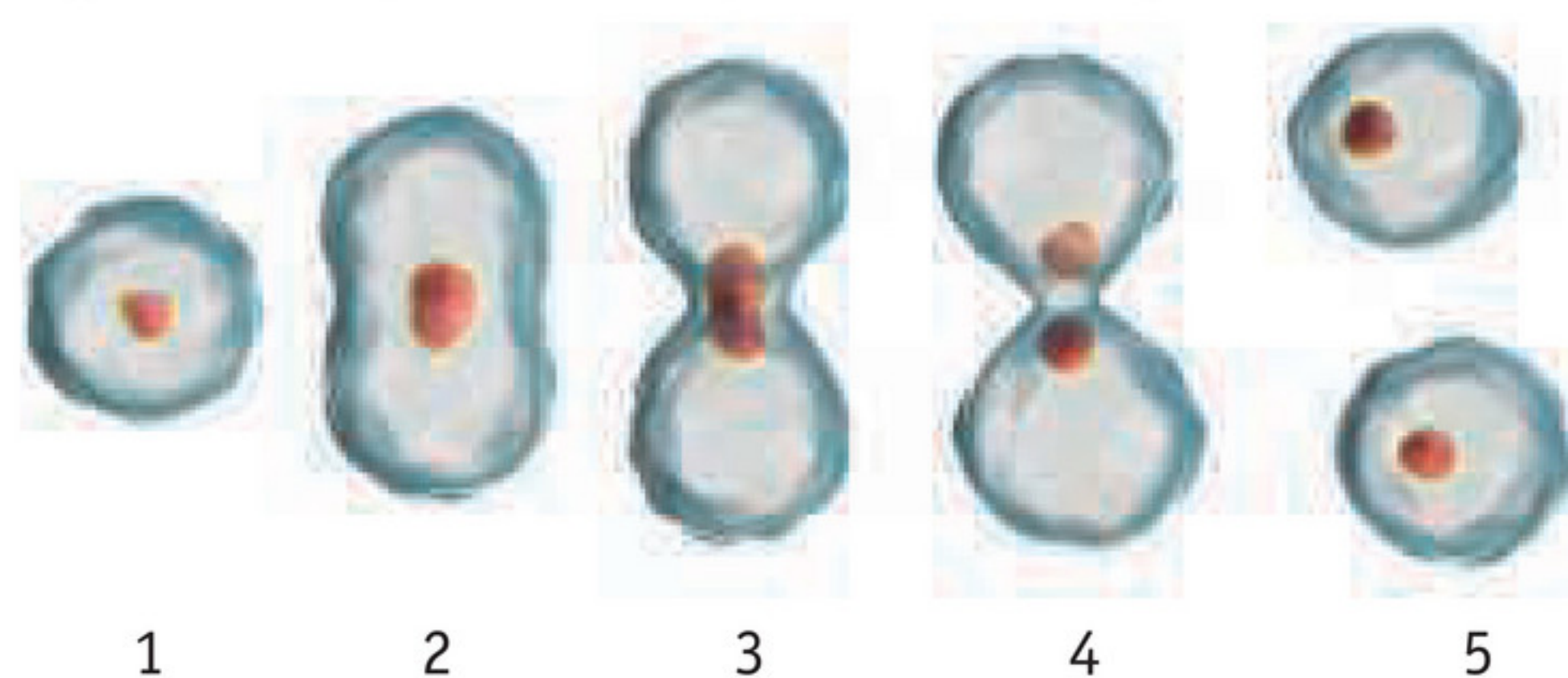
INSIGHT

6

Figure 6 shows the division of a body cell of an elephant in five stages. A body cell in an elephant contains 56 chromosomes.

- a** How many chromosomes does the nucleus contain in stage 2? Explain your answer.
- b** How many chromosomes does each nucleus contain in stage 5?
- c** Can you see the chromosomes in stage 5 under a microscope? Explain your answer.

fig. 6 An elephant's body cell is dividing.



7

Specialised cells often lose their ability to divide.

- a** How is it that there are always still cells in your body that are capable of dividing?
- b** One daughter cell might develop into a muscle cell, another into a liver cell and yet another into a nerve cell.
How can the cells of an organism specialise like this when they all have the same genes in their nucleus?

+ 8

The cell cycle does not go at the same speed for all cells that divide.

- a** Is the cell cycle for bone cells faster in a teenager or in an adult? Explain your answer.
- b** When you have a wound, new blood vessels grow when the cells in the wounded blood vessels start dividing. This lets the wound heal.
Does the cell cycle in the cells in the blood vessels of a wound go at the same speed or faster than in a blood vessel that isn't damaged? *the same speed / faster*
- c** It is important that cell division starts and stops on time.
What would be the problem if a daughter cell started dividing again too quickly?

HOW IT FITS TOGETHER biology in professional life**DERMATOLOGIST**

Sylvia is a dermatologist. That's a doctor who treats patients with skin, nail and hair problems. This field is very broad so Sylvia has specialised further, in treating skin diseases such as psoriasis. Patients with psoriasis have inflammation in their skin, and the skin cells divide abnormally quickly. This leads to too many cells that don't get the chance to develop into specialised skin cells. As a result, the skin starts to flake. If your father or mother has psoriasis, the chance that you will get the disease is 10%. If both your parents have psoriasis, that chance is 50%.

fig. 7 Sylvia the dermatologist.**9**

Read the text about a 'Dermatologist'.

- a** Do skin cells have cell walls? *yes / no*
And do skin cells have vacuoles? *yes / no*
- b** What goes wrong in psoriasis: the cell division or the cell cycle?
the cell division / the cell cycle
- c** Is the characteristic of getting psoriasis stored in your DNA? Explain your answer.

 Go to the *Flash cards* and the *Test yourself* section.

How it fits together

BAOBAB TREES ARE DYING

In the countryside in Africa, there are huge, strangely shaped trees called baobabs.

Baobabs can live up to a thousand years old. They consist of several tree trunks that have grown together. That is why they can become so huge. The trunks of the baobab tree often form a circle with open space in the middle. These open spaces are used by people as water storage places, homes, shops, chapels or even a prison. The tree trunks themselves can also be hollow. That can be because of a fungal infection or it may be the work of animals. Elephants know exactly what they can find in those tree trunks: water. The middle part of the tree trunk is as soft as a sponge and contains a lot of water. The elephants use their tusks to make a hole in the bark, pull the bark loose and when they get to the centre, quench their thirst by chewing on the fibres.

USEFUL TREE

Every part of the baobab tree can be used by people. The leaves have a lot of iron and if cooked, can be eaten, like spinach. The flowers are edible too. The local people make juice, jam and beer from the fruits, which look like dead rats. The fruit pulp has 6 times as much vitamin C as oranges. The seeds are a coffee substitute when roasted, or they can be pressed to make oil. The wood fibres from the tree trunks are used to make cords, fishing lines, ropes and baskets. Young baobab plants have a tap root (a long straight root) that is edible too. The roots are also used to make a red dye.

fig. 1 A baobab tree.



DROUGHT

Baobabs can live to be 2500 years old, but in Africa nine of the thirteen oldest baobab trees have died in the past few years. The largest was more than 1500 years old, had a circumference of 47 metres and was 22 metres tall. Before the tree started to crack apart in 2016, there was a cocktail bar in a hollow in the trunk with room for fifteen guests. The trees seem to be victims of climate change. Scientists think that higher temperatures have either killed the trees directly or made them weaker so that they are more vulnerable to drought and diseases. The trunks of the trees that had died were found to contain much less water than normal. Researchers found that water only made up 40% of the tissue, compared with 75% to 80% in normal circumstances.

Baobabs are not only useful for humans, they are also important for a lot of organisms in the dry African savannahs. The death of the baobabs is therefore a great loss for both the local people and nature.

EXERCISES

1

The roots of young baobab plants are edible.

- a What other parts and organs of the baobab tree are edible?
- b What makes the roots of young baobab plants suitable as food?
- c The roots of the baobab tree are also used to make a red dye.
What cell organelles does the dye probably come from?

2

Cords, fishing lines and ropes are made from the trees' wood fibres.

- a What are wood fibres? *lamina / leaf stalks / plastids / vascular bundles*
- b Which three characteristics make wood fibres suitable for making cords, fishing lines and ropes?

3

If it gets very hot, the stomata in the baobab's leaves close up.

- a Does photosynthesis still take place then? Explain your answer.
- b All baobab trees lose their leaves at the start of the dry season. No photosynthesis takes place during the dry season, which lasts nine months. During this period, the tree uses very little energy.
But where does the baobab tree get that energy from?

4

Scientists think that drought could be one reason why the baobab trees are dying.

- a What effect does a shortage of water have on the production of glucose?
- b Explain why photosynthesis is important for cell division.
- c What effect can drought have on the recovery and growth of baobab trees?

5

In a large baobab tree, several hollow tree trunks have grown together to form one tree.

- a Why is it difficult to determine the age of such a baobab tree?
- b This baobab tree is enormous and it has 160 chromosomes in each nucleus.
Does a large organism always have more chromosomes than a small organism?
- c Does this baobab tree have the same genes in the chromosomes in all its cells?
Explain your answer.

6

The baobab tree is also called the 'dead rat tree' by the local people.

- a Which part of the tree is responsible for that nickname?
- b Another local name for the tree is the 'upside-down tree'.
Explain that nickname using figure 2.

fig. 2 Baobab trees on Madagascar.



7 Single-celled organisms

LEARNING OBJECTIVE

2.7.13 You can explain how organism can consist of a single cell.

► Practical activities 15 and 16

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	2.7.13
Remembering	1a, 2
Understanding	1b
Using	
Analysing	

Many plants and animals are made up of organ systems, organs, tissues and cells. But some organisms consist of just a single cell.

SINGLE-CELLED ORGANISMS

Organisms have life processes such as breathing and feeding. Many organisms have organs and organ systems that carry out those functions. But there are also **single-celled organisms**. These are living creatures that consist of just one cell. In single-celled organisms, that one cell has all the life processes: breathing, feeding, excreting, sensing, moving, reproducing and growing.

Two examples of single-celled organisms are the **amoeba** (pronounced 'a-MEE-buh') and the **paramecium** (pronounced 'para-MEE-see-um'). Both species live in water, for instance in ditches and pools. But they are also found in shower drains and in the water in a vase of flowers.

AMOEBA

An amoeba (see figure 1) can keep changing shape. The cytoplasm can flow in a particular direction and create protrusions known as **pseudopods**. Moving the cytoplasm using the pseudopods allows the amoeba to move (see figure 2).

fig. 1 Amoeba (135× magnification).

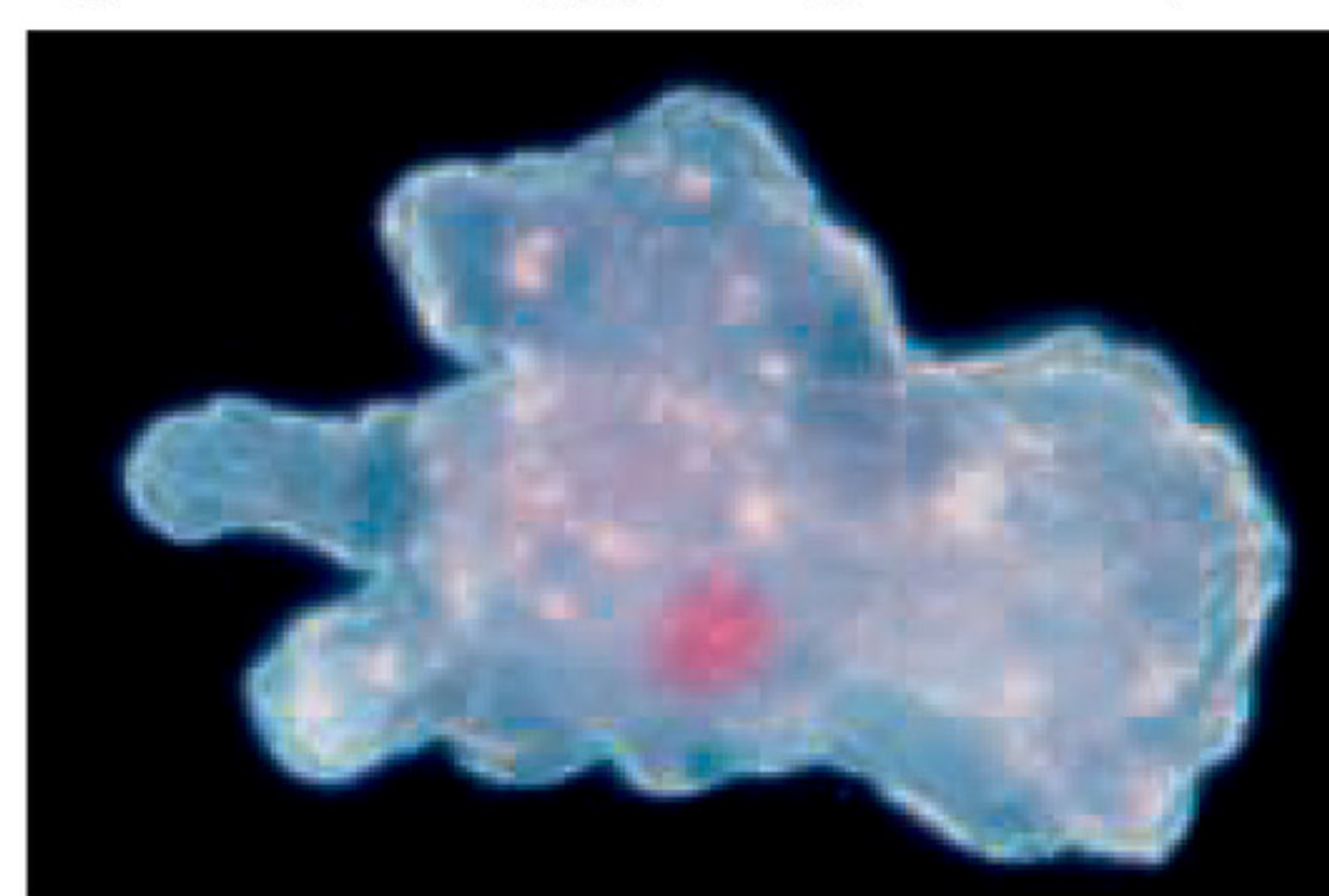
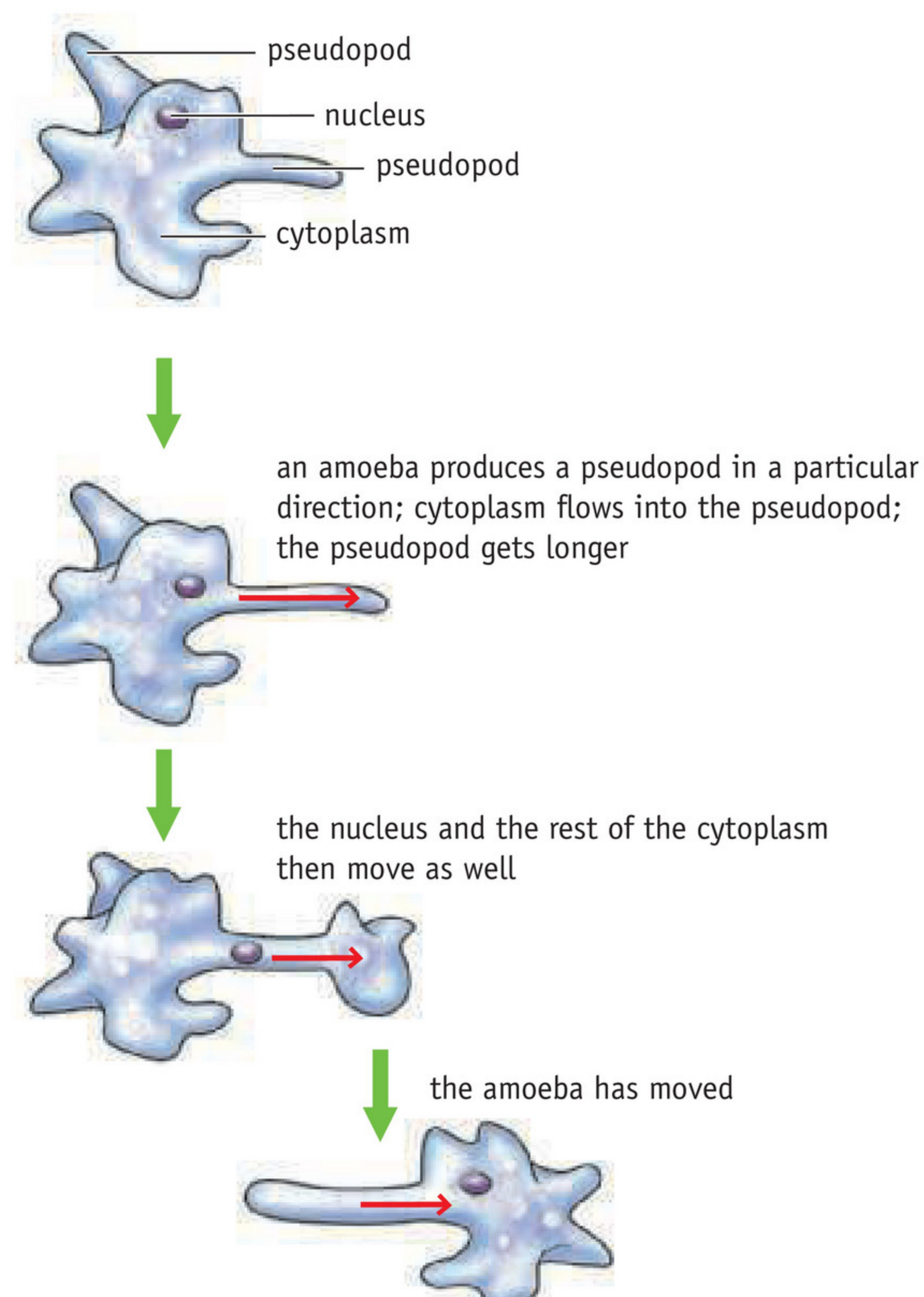


fig. 2 How an amoeba moves forwards (diagram).

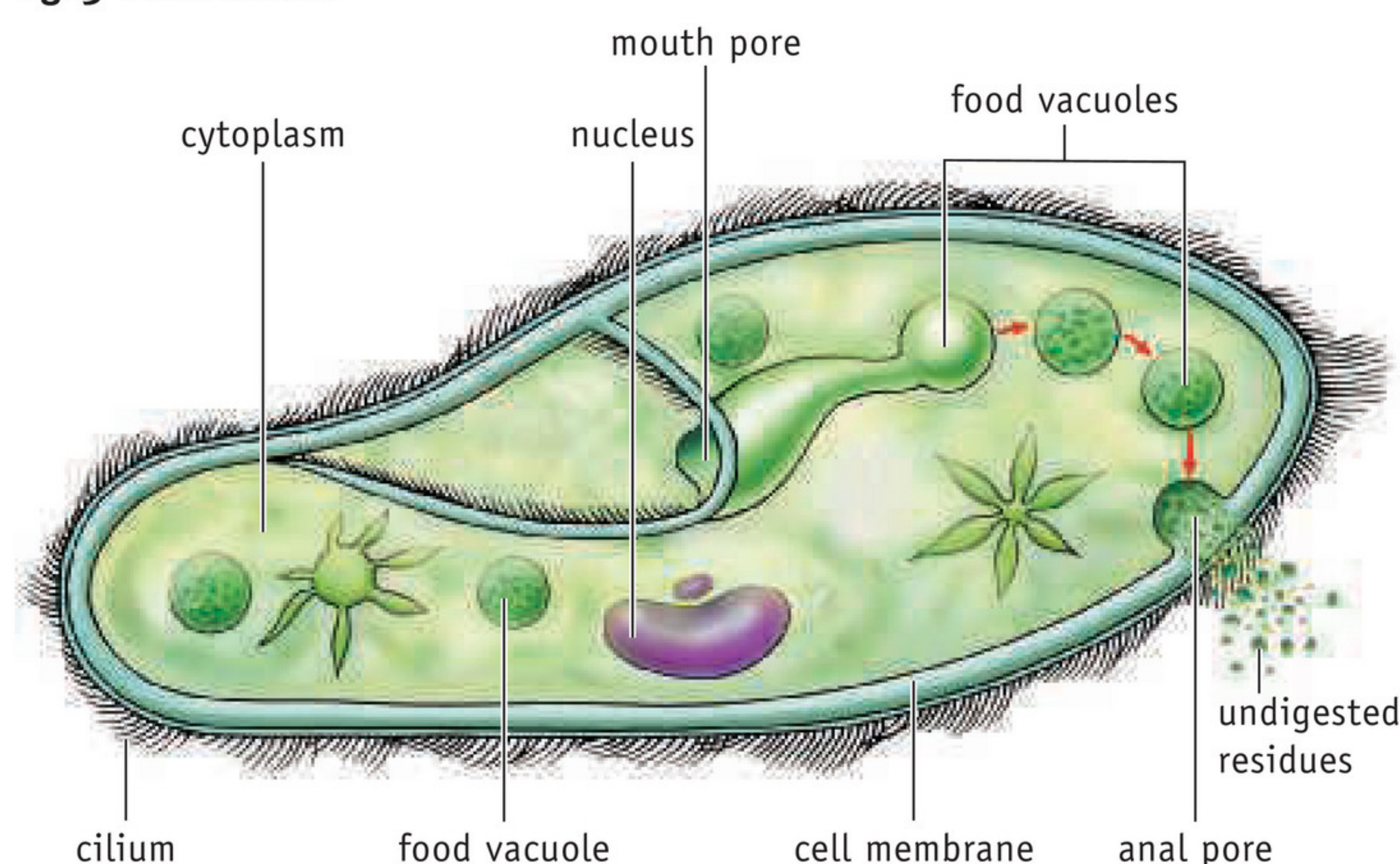


By forming pseudopods, the amoeba can reach food and take it in. It does that by folding itself around the food and enclosing it. The food of an amoeba includes bacteria. The enclosed bacterium is taken into the cell and into a vesicle called the **food vacuole**. This is a different type of vacuole to the vacuoles in plant cells. The bacterium is digested (broken down) in the food vacuole. The digested substances are absorbed into the cytoplasm. Undigested residues are eliminated through the cell membrane.

PARAMECIUM

A paramecium (see figure 3) has a more complex structure than an amoeba. There are small **cilia** (singular: cilium) on the cell membrane. These are vibrating hairs that wave around in the water, allowing the paramecium to move. The cilia also push food towards the **mouth pore**. The mouth pore is an indentation in the cell surface. Via the cell mouth, the food ends up in a food vacuole. This is where the food is digested. The digested substances are absorbed into the cytoplasm. Undigested residues are eliminated through the **anal pore**.

fig. 3 Paramecium.



EXERCISES

1

Figure 4 shows you how an amoeba feeds.

a Write down the correct letters next to the parts.

bacterium = ...

cell membrane = ...

cytoplasm = ...

pseudopod = ...

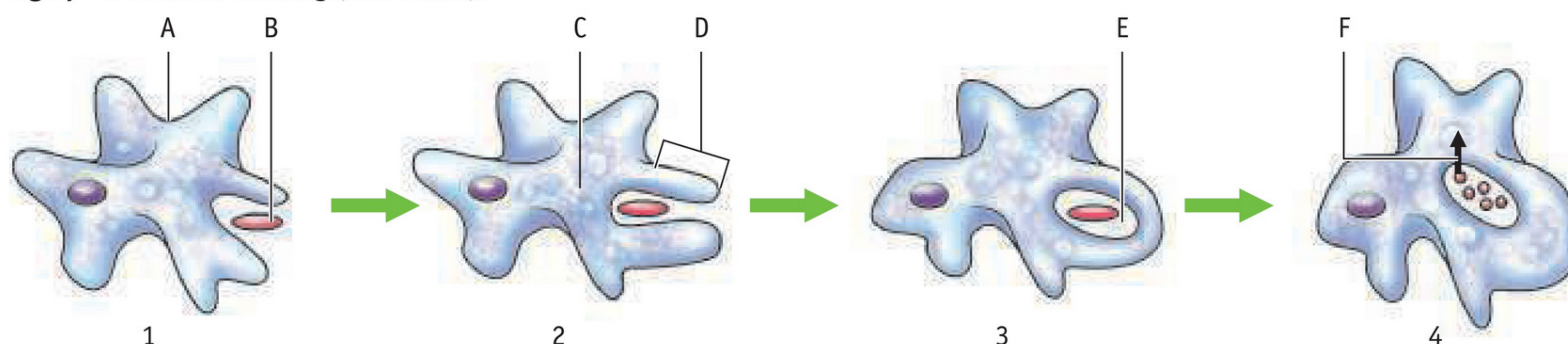
digested substances are absorbed into the cytoplasm = ...

food vacuole = ...

b Put the steps in the correct sequence.

- The amoeba produces pseudopods that surround a bacterium (food particle).
- The bacterium is digested in the food vacuole.
- The pseudopods enclose the bacterium; a food vacuole is formed.
- An amoeba detects a bacterium.

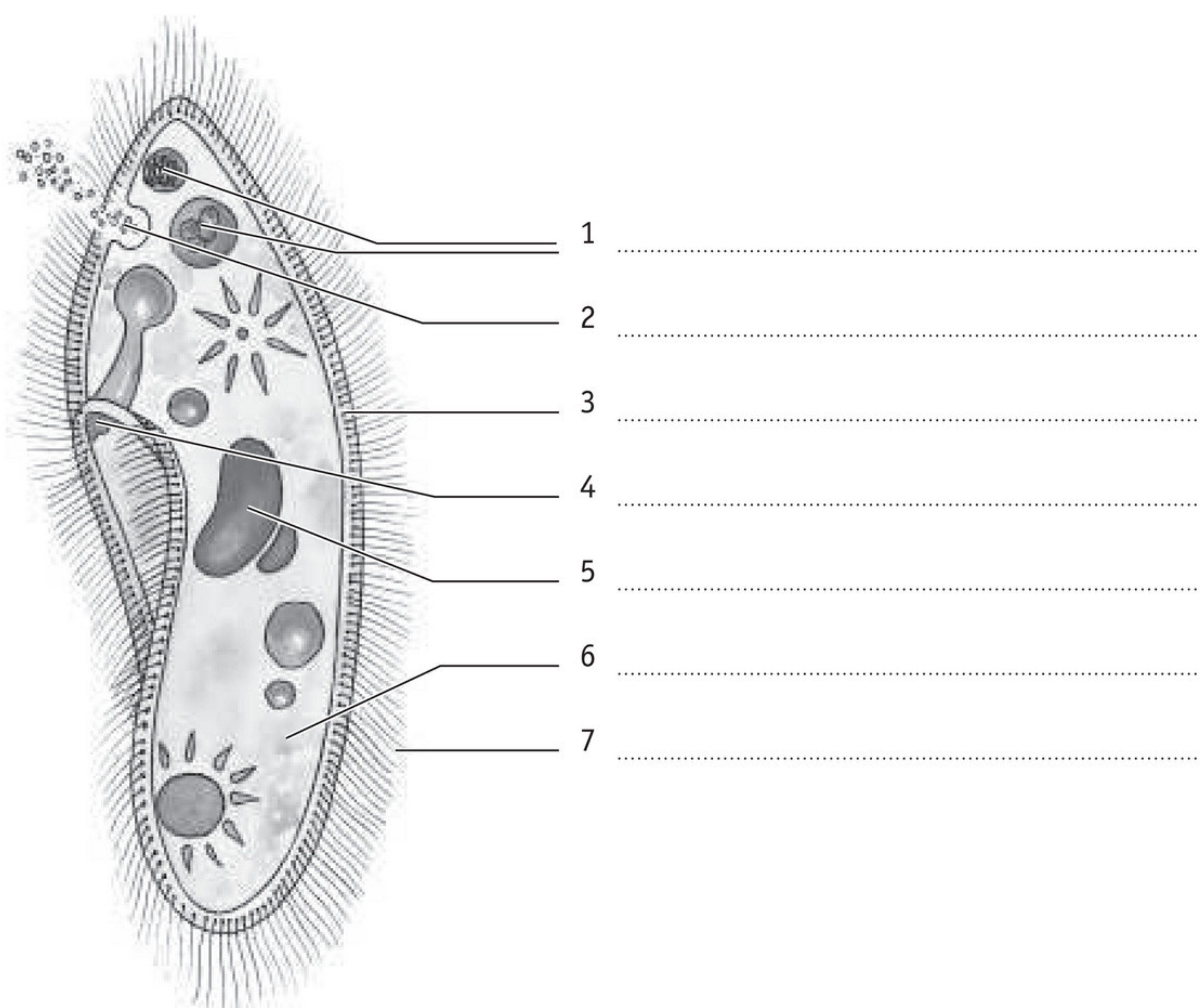
fig. 4 An amoeba feeding (schematic).



2

Write down the names next to the numbered parts in figure 5.

fig. 5 Paramecium.



 Go to the *Flash cards*.

8 DNA testing

LEARNING OBJECTIVE

2.8.14 you can explain that DNA tests can be used to show that people are related.

► Practical activity 17

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	2.8.14
Remembering	
Understanding	3a
Using	1a, 3b
Analysing	1b, 2

People all look different. That is because of differences in their DNA. No one has precisely the same DNA as you unless you are one of a pair of identical twins.

EVERYONE IS DIFFERENT

Many characteristics can differ between people, for example their hair colour, the colour of their eyes, how high they can jump and the shape of their nose. That is because people’s DNA is different, except in the case of identical twins. They look the same because there are no differences in their DNA. Because each person has unique DNA, you can use a person’s DNA to identify them.

Children get their DNA from their parents. As a result, members of the same family look more like each other than people who are not related. So you can also use DNA to determine whether someone is related to you. This is called **DNA kinship analysis** or familial testing.

fig. 1 Every human being is unique.



CRIME INVESTIGATIONS

The police can use DNA testing to solve crimes. Cells belonging to the offender can often be found at the scene of a crime. If the victim scratched the offender, some of the offender’s skin can often be found under the victim’s fingernails. Saliva, blood, hair or semen may also be found.

DNA tests can be used not just to track down an offender but also to prove that someone cannot be the offender. In the murder investigation in figure 2, a DNA kinship analysis was carried out. Tests on the murderer’s DNA had shown that it had to be a man of Western European ethnicity. About eight thousand men who lived in the area were asked for a sample of cheek lining cells. These tests let them find the man whose DNA was on the victim.

fig. 2

Suspects in murder case shown to be innocent

For months, the police saw an asylum seeker as the only suspect in a murder investigation. But DNA tests showed he could not possibly be the murderer. Traces of the murderer were found on the victim's body. The suspect's DNA, which was analysed as a matter of urgency, turned out to be completely different to the traces that had been found. The police have detained five new suspects, all of whom were released following DNA tests.

CREATING A DNA PROFILE

To do a DNA test, a DNA profile is created. A **DNA profile** is a drawing or table of someone's DNA. A DNA profile is created in four steps: isolating, cutting into pieces, replicating and measuring.

1 Isolating

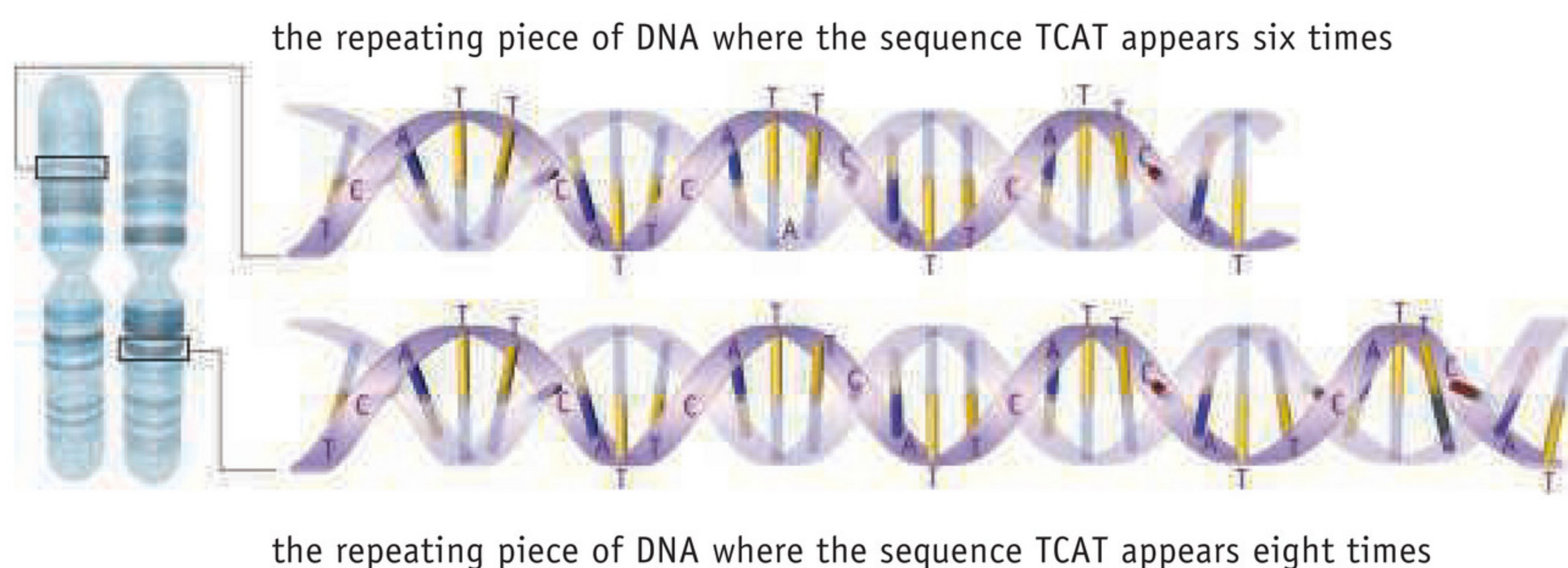
First the DNA is extracted from the cell nucleus. Substances are added to the cells that make them fall apart, which releases the DNA.

2 Cutting into pieces

Human cells have 46 chromosomes. Chromosomes come in pairs that belong together. Each of your cell nuclei has 23 chromosome pairs. In each pair, one chromosome comes from your father and the other from your mother.

The DNA of a chromosome pair contains repeated pieces, where a certain sequence of bases is repeated in both chromosomes. But the number of repetitions can differ. For example (see figure 3), the sequence TCAT may appear 6 times on one chromosome and 8 times on the other chromosome. These repeating pieces of DNA can be cut from the DNA using special substances.

fig. 3 Repeating piece of DNA



3 Replicating

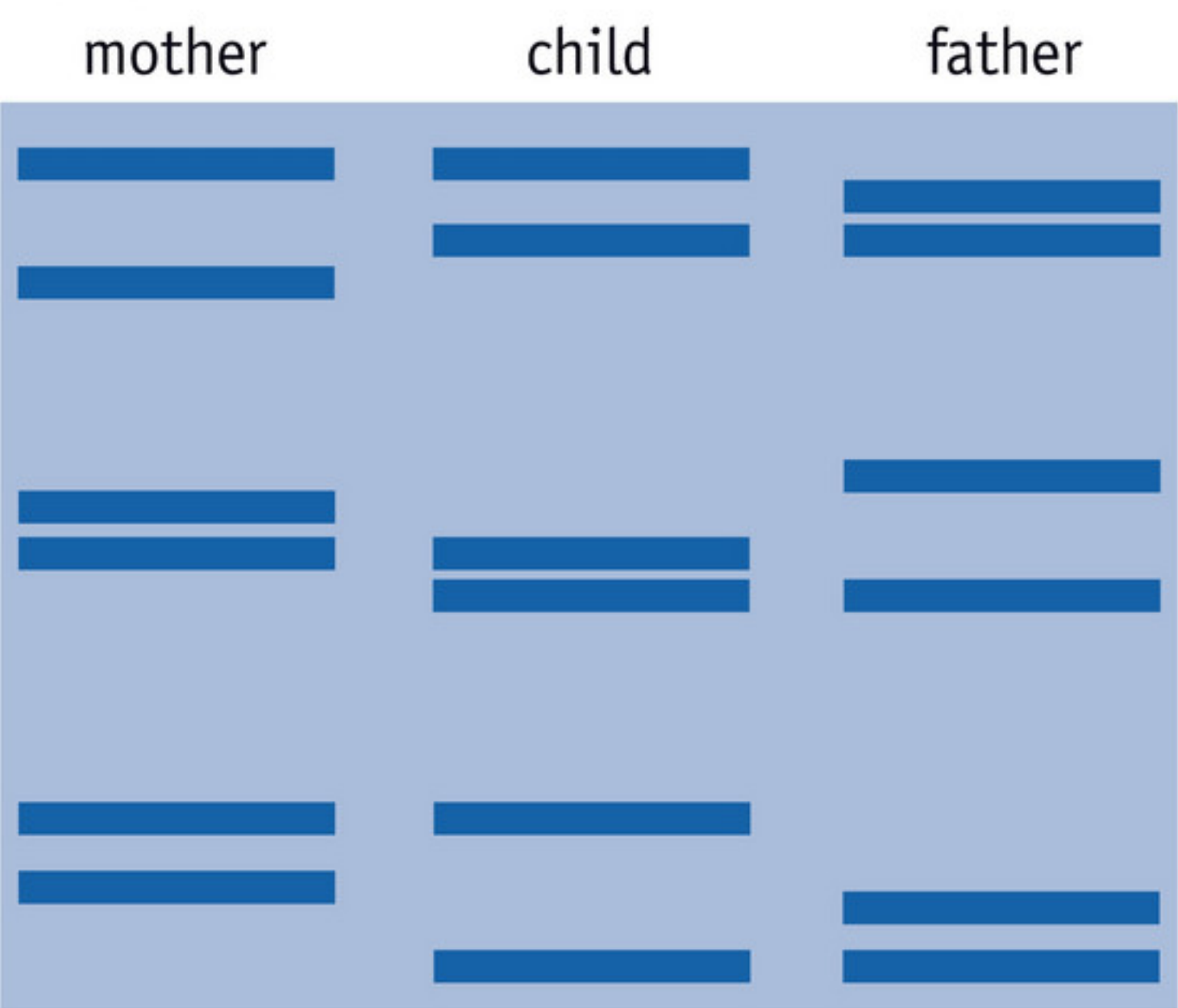
Often, there is not enough DNA for further investigation. So a special technique called amplification is used to make lots of copies of the pieces of DNA.

4 Measuring

Finally, the pieces of DNA are put in a machine. The machine sorts the pieces by length (i.e. the number of repetitions). A computer produces a picture of the pieces, for example as bars or stripes. Those stripes are called **bands**. Figure 4 shows a drawing of three sets of two bands for a mother, a child and a father. In each set, one of the two bands for the child is from the mother and one is from the father.

This matching can also be done using the DNA of a suspect and DNA from cells that have been found.

fig. 4 DNA profile (schematic).



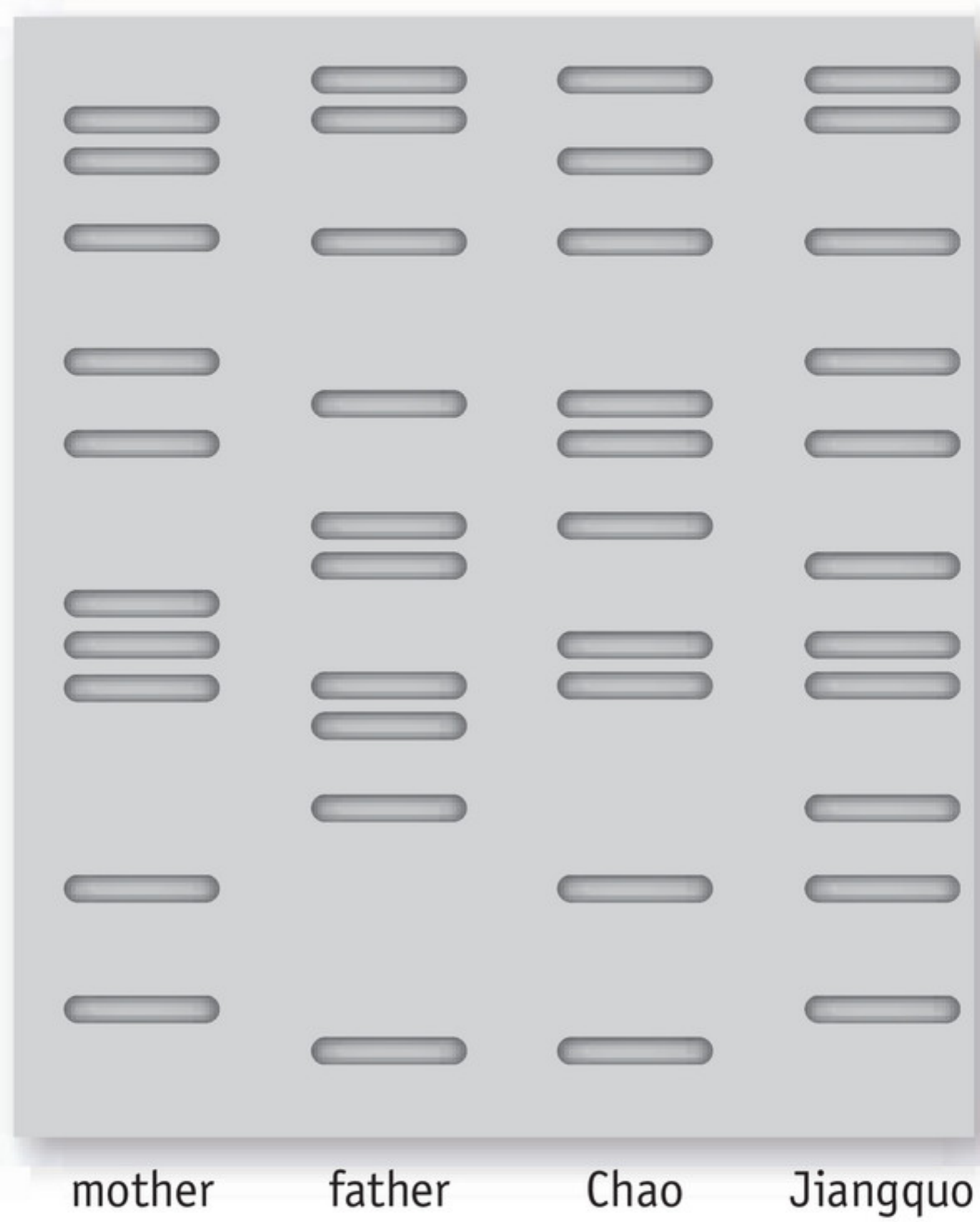
EXERCISES

1

Chao’s parents died in a tragic car accident. His parents were very rich. At the funeral, someone came up to him and introduced himself as Chao’s brother Jianguo. Chao had never heard of him and thought he was just out to get the inheritance. Chao suggested carrying out a DNA kinship analysis (‘familial testing’). Figure 5 is a schematic drawing of part of the results of the analysis.

- a Could Jianguo really be Chao’s brother, based on this part of the DNA kinship analysis? Explain your answer.

fig. 5



- b** Usually, ten or more pieces of repeating DNA are examined in a kinship analysis. A repeating piece of DNA is called a marker. Sometimes it is possible to draw conclusions from a smaller number of markers. Table 1 shows the results of a kinship analysis in which five markers were examined. The numbers give the number of repetitions of each marker.
- Can it be concluded that the woman is not the child’s biological mother, based on these results? What about the man as the biological father? Explain your answer.

Table 1

	Female	male	Child
Marker 1	7, 8	8, 12	8, 12
Marker 2	12, 19	12, 14	12, 13
Marker 3	3, 27	26, 27	23, 27
Marker 4	11, 18	14, 15	9, 18
Marker 5	6, 12	9, 14	6, 14

2

A forensic investigation is an investigation into the causes of crimes by examining traces left by offenders. DNA tests play an important role. But the information from DNA tests is often not enough to determine the offender. In a burglary, the homeowner was killed with a knife. The blood from a second person was found on the floor next to the blood of the victim. A DNA profile was made from the blood of this second person. It turned out that this DNA profile matched the DNA profile of a friend of the victim’s wife. However, just because the DNA profile of the blood that was found matches the DNA profile of the wife’s friend, this does not mean the friend was the culprit. Explain why.

3

- In DNA investigations, a suspect often provides cells from their cheek lining.
- a** Explain why the result of the DNA test would be the same if the suspect provided cells from their blood, skin or hair roots.
- b** A woman claims she is the daughter of the Belgian king.
Can a DNA test be used to determine whether the woman is right? Explain your answer.

 Go to the *Flash cards*.

Learning how to do research

1

THE MICROSCOPE

► Basics 1 | ► Learning objective 2.0.15

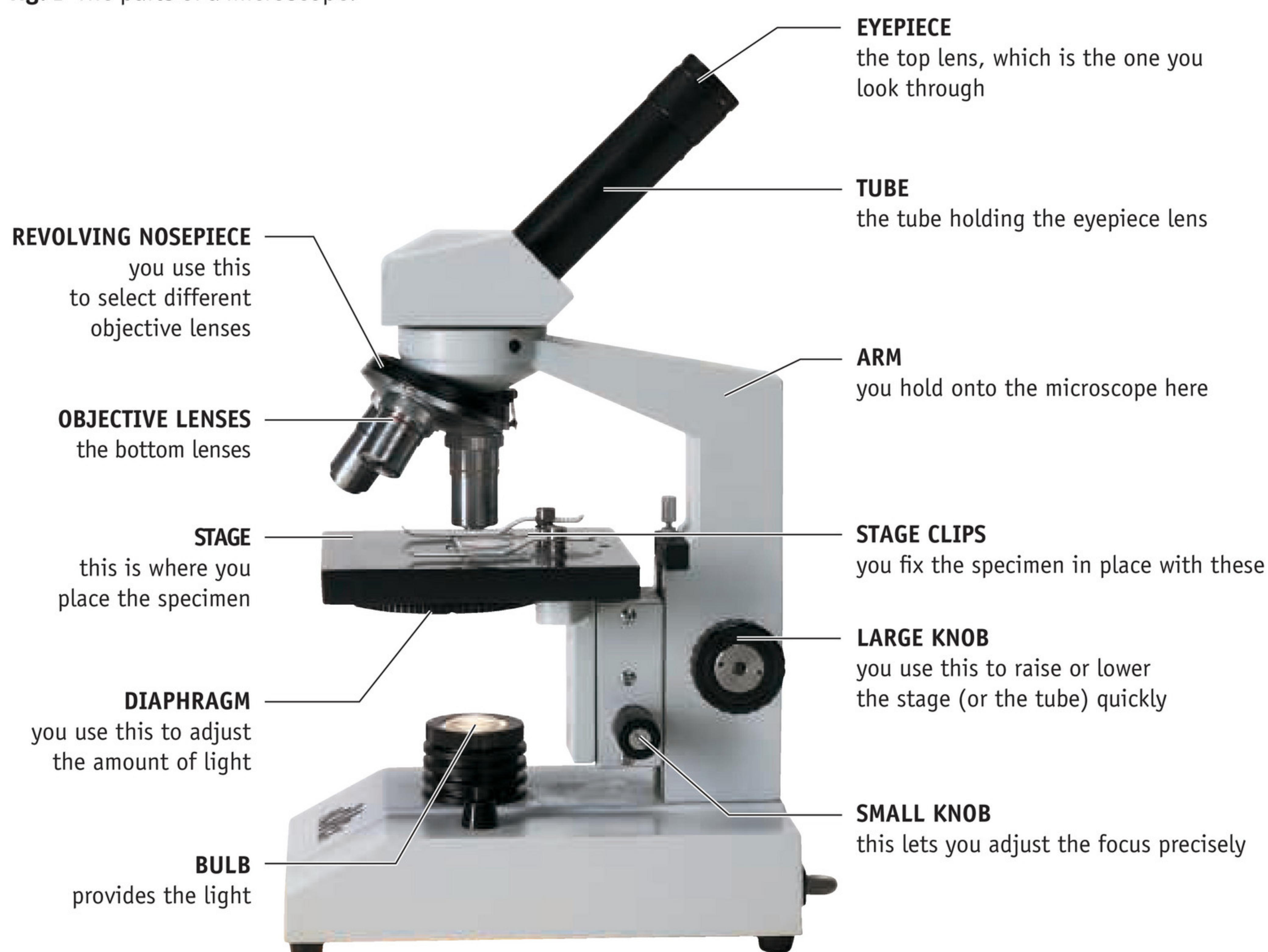
TWO KINDS OF MICROSCOPE

There are different kinds of microscopes. The most common are the light microscope and the electron microscope. A **light microscope** lets you magnify objects up to 1000 times, but an **electron microscope** lets you magnify them up to almost 1,000,000 times. At school, you use a light microscope to look at cells, for instance. The microscopes at school have a magnification of up to approximately 600 $\times$.

PARTS OF A MICROSCOPE

A light microscope consists of a lot of parts (see figure 1). You hold on to a microscope by the **arm**. You look through the top lens, the **eyepiece lens**. Most microscopes have two eyepiece lenses, one that magnifies 5 times and one that magnifies 10 times. You usually use the eyepiece lens that magnifies 10 times. The eyepiece lens fits loosely inside the **tube**, so you should never hold the microscope upside down, or else the eyepiece lens will fall out! At the bottom of the tube is the **revolving nosepiece**. This is a rotatable disc to which the **objective lenses** are attached. There are usually three objective lenses attached to the revolving nosepiece. The magnification is shown on the objective lens. You can get different magnifications by using different combinations of eyepiece lens and objective lens. You calculate the total magnification by multiplying the eyepiece lens magnification by that of the objective lens. So if you use an eyepiece lens that magnifies everything 5 $\times$ and an objective lens that magnifies everything 10 $\times$, the total magnification is 50 $\times$.

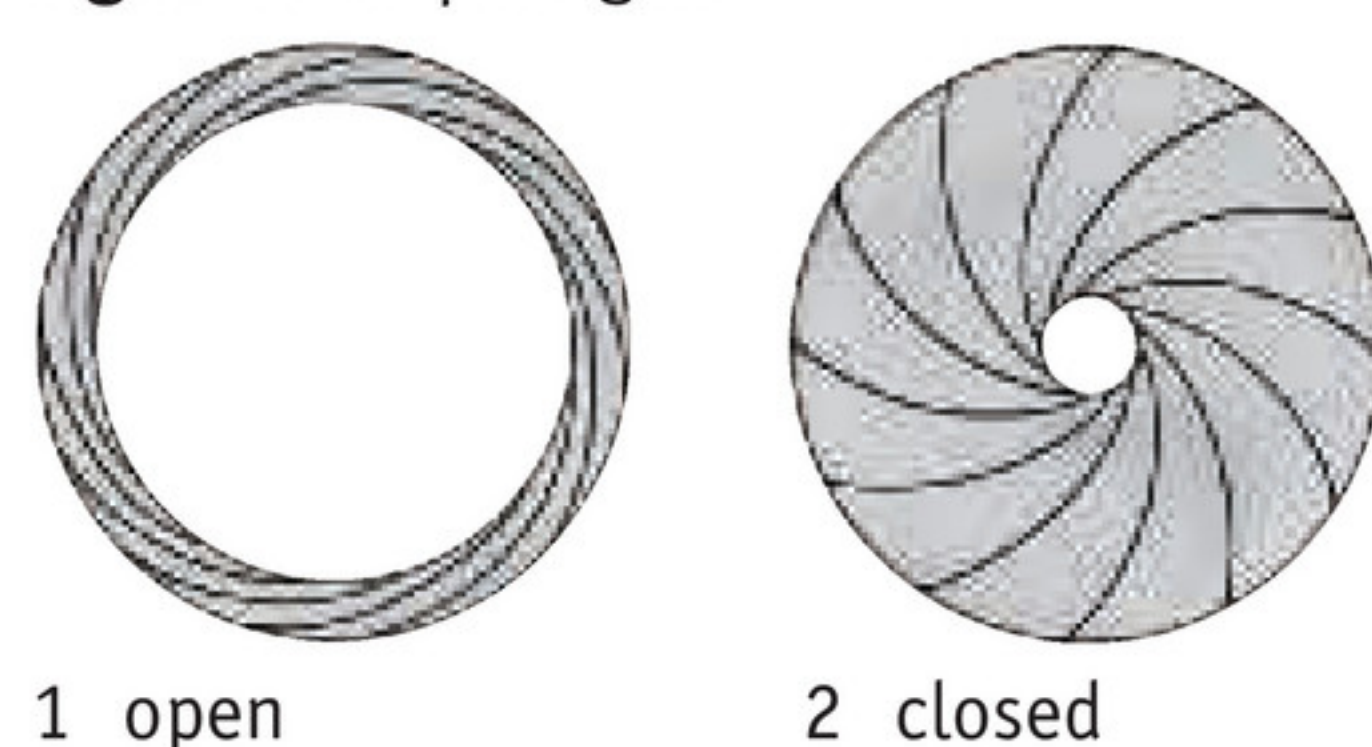
fig. 1 The parts of a microscope.



Most school microscopes have two knobs on the arm, a **large knob** and a **small knob**. Turning these knobs changes the distance between the **stage** and the objective lenses. In some microscopes, the stage moves up or down, whereas in other microscopes it is the tube and the objective lenses that move.

The object that you want to examine under the microscope is called the **specimen**. You put the specimen on the stage, in the middle above the opening. You clamp the specimen in place with the **stage clips**. There is a **diaphragm** under the stage. You use this to adjust the amount of light (see figure 2). The light comes from the lamp under the table. Some microscopes have a rack stop (a small screw). The **rack stop** prevents the objective lens from touching the specimen. You must not turn the rack stop screw yourself.

fig. 2 A diaphragm.



PREPARATION

A specimen consists of a thick piece of glass, the **slide**, and a thin piece of glass, the **coverslip**. The object you want to examine is placed between the slide and the coverslip. The object is usually in a liquid. If you are using a light microscope, light will shine through the object and so the object has to be very thin for this. Many objects can be bought as ready-made specimens, for example a piece of skin with a hair follicle (see figure 3).

fig. 3 A ready-made specimen.



EXERCISES

1

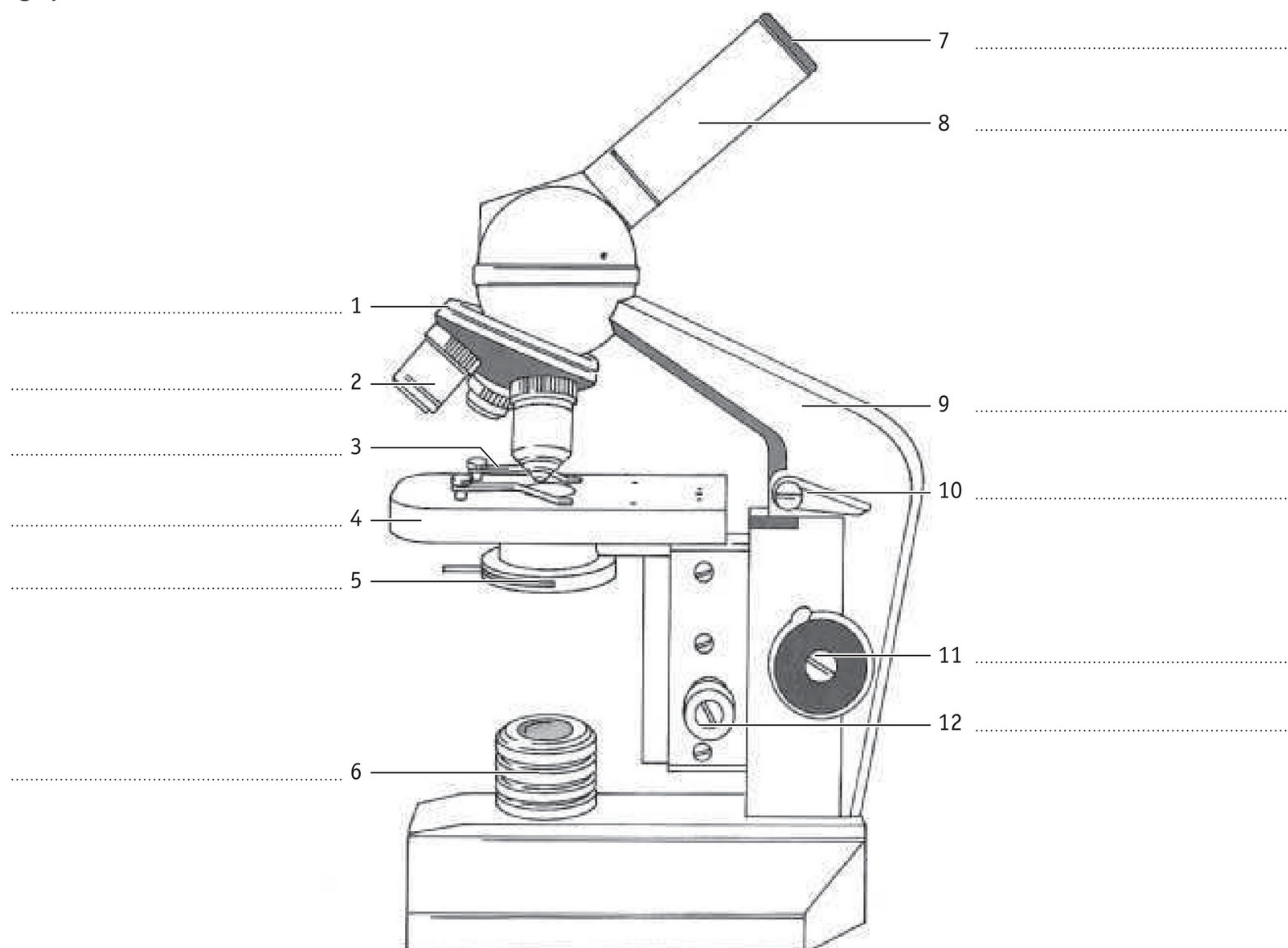


Figure 4 shows a diagram of a microscope.

a Write down the names of the numbered parts.

b Use arrows to show the path the light takes through the microscope.

fig. 4



2

Figure 5 shows three eyepiece lenses with magnifications of 5 $\times$, 10 $\times$ and 15 $\times$, and three objective lenses with magnifications of 4 $\times$, 10 $\times$ and 40 $\times$.

Give all the possible magnifications you can get with these eyepiece lenses and objective lenses.

fig. 5



1 eyepiece lenses

2 objective lenses

2

USING A MICROSCOPE

► Basics 1 | ► Learning objective 2.O.16 | ► Practical activities 1 to 4 and 8 to 16

When you look at a specimen through a microscope, you should always start by choosing the lowest magnification and focusing. That will make it easy to find the specimen on the slide. It also reduces the chance of you touching the specimen with an objective lens. Figures 6 and 7 show how you should focus the microscope. Figure 8 tells you what to do if you can't see anything.

fig. 6 Focusing at the lowest magnification.



1 Turn the large knob to raise the tube all the way up (or lower the stage all the way down). Turn the smallest objective lens until it is above the stage.



2 Place the specimen between the clips. Make sure that what you want to look at is in the middle above the opening in the stage.



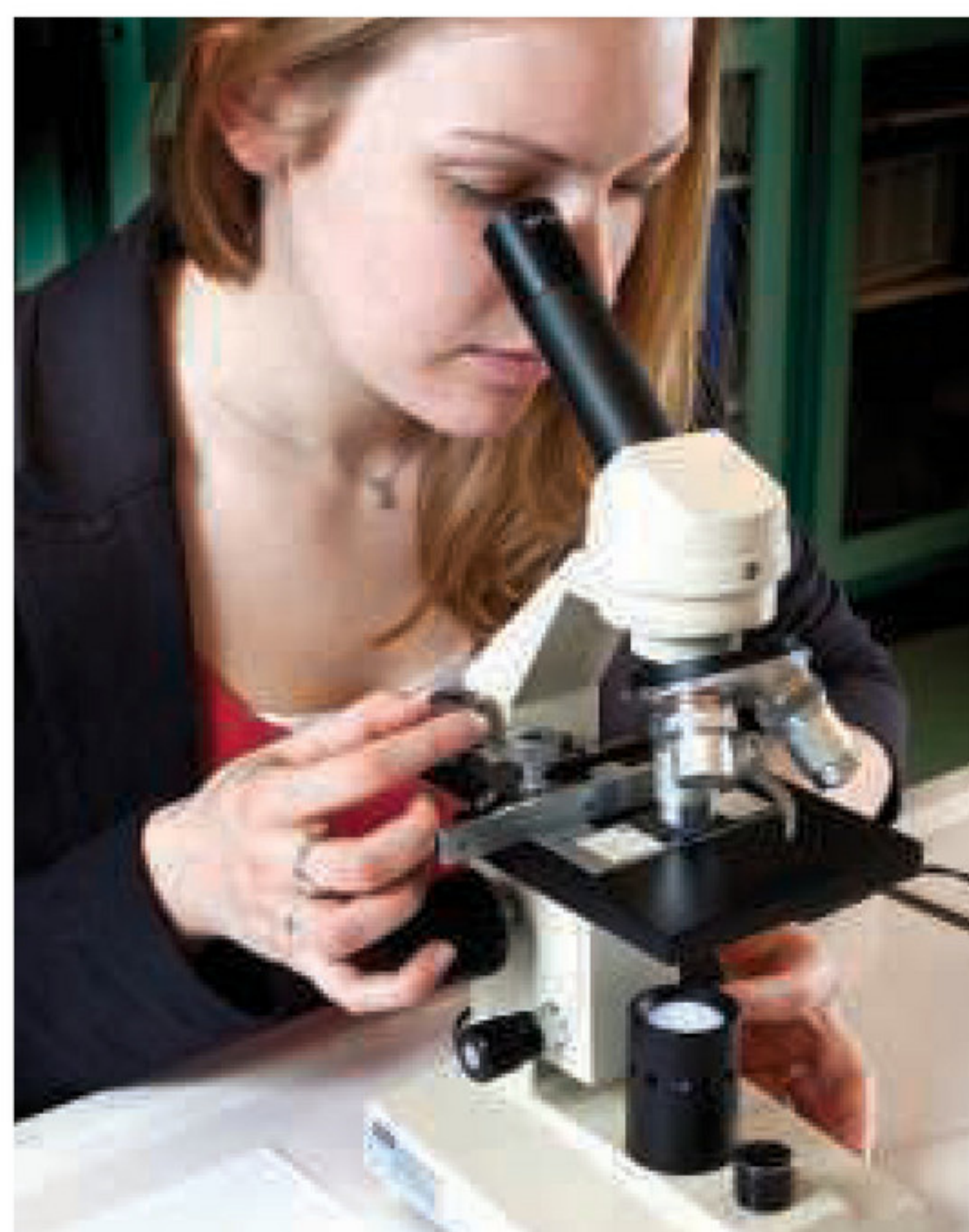
3 Look at the microscope from the side. Turn the large knob to lower the tube all the way down (or raise the stage all the way up). Make sure that the specimen does not touch the objective lens.



4 Look through the eyepiece lens. Turn the large knob to raise the tube slowly (or lower the stage). Stop when the image is reasonably well focused.



5 Use the small knob to focus the image precisely.

fig. 7 Focusing at a higher magnification.

1 You have already focused at the lowest magnification. Look through the eyepiece lens. Shift the specimen so that what you want to magnify further is in the middle of the image.



2 Look at the microscope from the side. Rotate the objective lenses to get the lens that is one size bigger. Do not turn the large knob.



3 Use the small knob to focus the image precisely.

fig. 8**If you don't see anything**

If you don't see an image, that might be for one of the following reasons:

- 1 You have not turned the revolving nosepiece properly and the objective lens is not precisely above the specimen. In most microscopes, the revolving nosepiece clicks into place.
- 2 The specimen is not placed properly above the opening in the stage.
- 3 You are using too high a magnification.
- 4 The diaphragm is not letting any light through.
- 5 The bulb is not switched on.

Check the above before you ask for help.

**EXERCISE****3**

You should always examine a specimen first at the lowest magnification.

- a Give two reasons for this.
- b Why must you never use the large knob to lower the tube (or raise the stage) when you are looking through the eyepiece lens?
- c If you examine an object using a high magnification, it is a good idea to use the small knob to keep adjusting the focus. Explain why.

3

PREPARING A SPECIMEN

► Basics 3 | ► Learning objective 2.O.17 | ► Practical activities 8 to 13 and 16

You use preparation materials when making a specimen. Figure 9 shows the preparation materials you will often need.

fig. 9 Preparation materials.



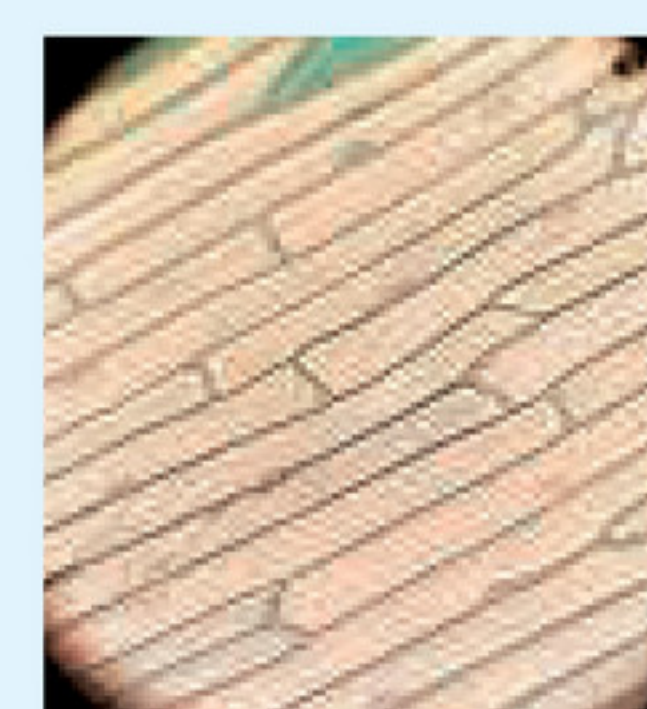
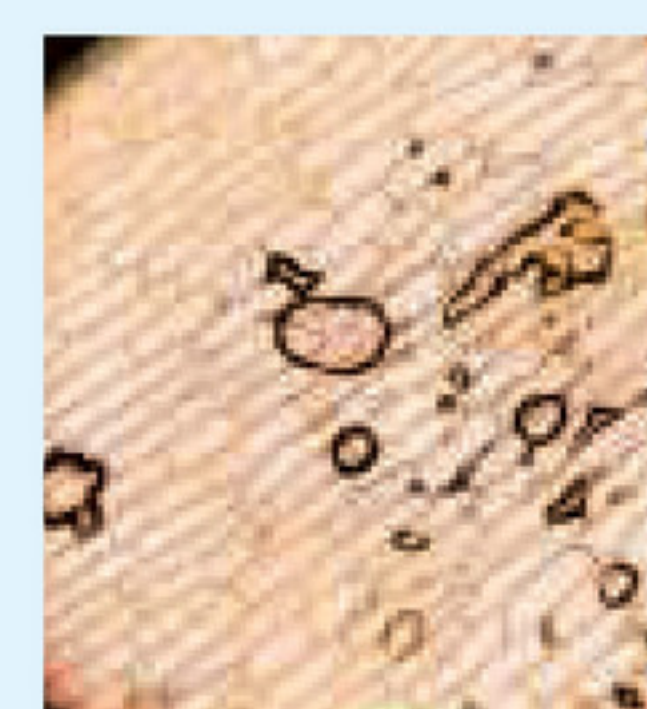
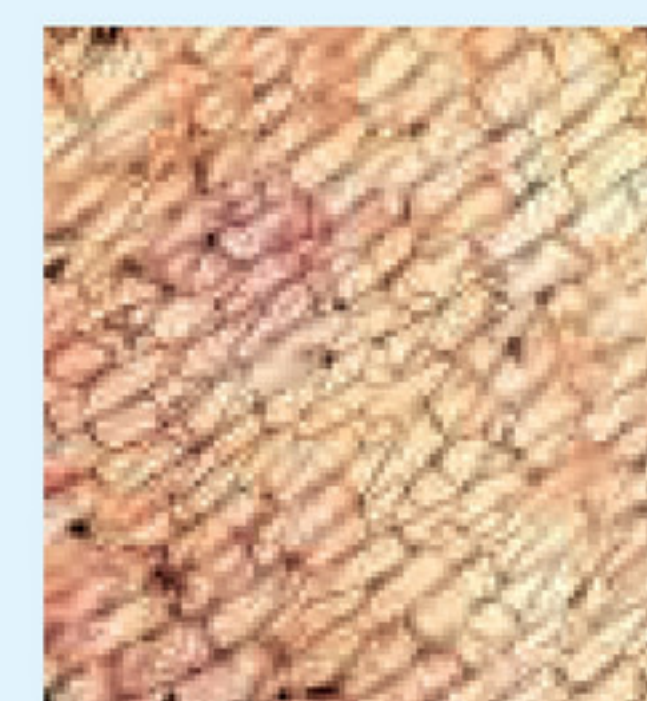
Figure 10 shows how you can make a specimen from the skin of an onion. An onion is made up of food storage leaves. You can remove the innermost layer of a food storage leaf as a thin transparent skin (see figure 10.2). Figure 11 shows you what a specimen should look like.

fig. 10 Making a specimen from the skin of an onion.

		
1 Take a slide and squeeze a drop of the stain (a dye solution) onto it.	2 Use tweezers to pull off a layer of skin from the inside of the food storage leaf of an onion. Cut off a piece of the skin with the blade. You only need a piece 1 cm long.	3 Place the piece of skin in the drop of dye solution. Make sure that the skin is not folded double.
		
4 Slide a coverslip over the drop of the stain, keeping it tilted at an angle.	5 Lower the coverslip slowly onto the slide using a mounted needle. There must not be any air bubbles in the specimen.	6 Remove excess stain with filter paper. Make sure you do not soak up any of the stain from under the coverslip.

fig. 11**This is what a specimen should look like**

- 1 If you see cells crossing each other, that means the skin is folded double. That may be because the piece of skin is too big. Find a spot where the skin is not folded double. If you can't, then take the specimen apart and make a new specimen with a smaller piece of skin.
- 2 If you see black circles, that means there are air bubbles in the specimen. That may be because you let the coverslip down onto the drop of stain too quickly. Lift up the coverslip at one edge using a mounted needle. Then let it down again, only very slowly this time.
- 3 If your specimen looks like this, that is good.



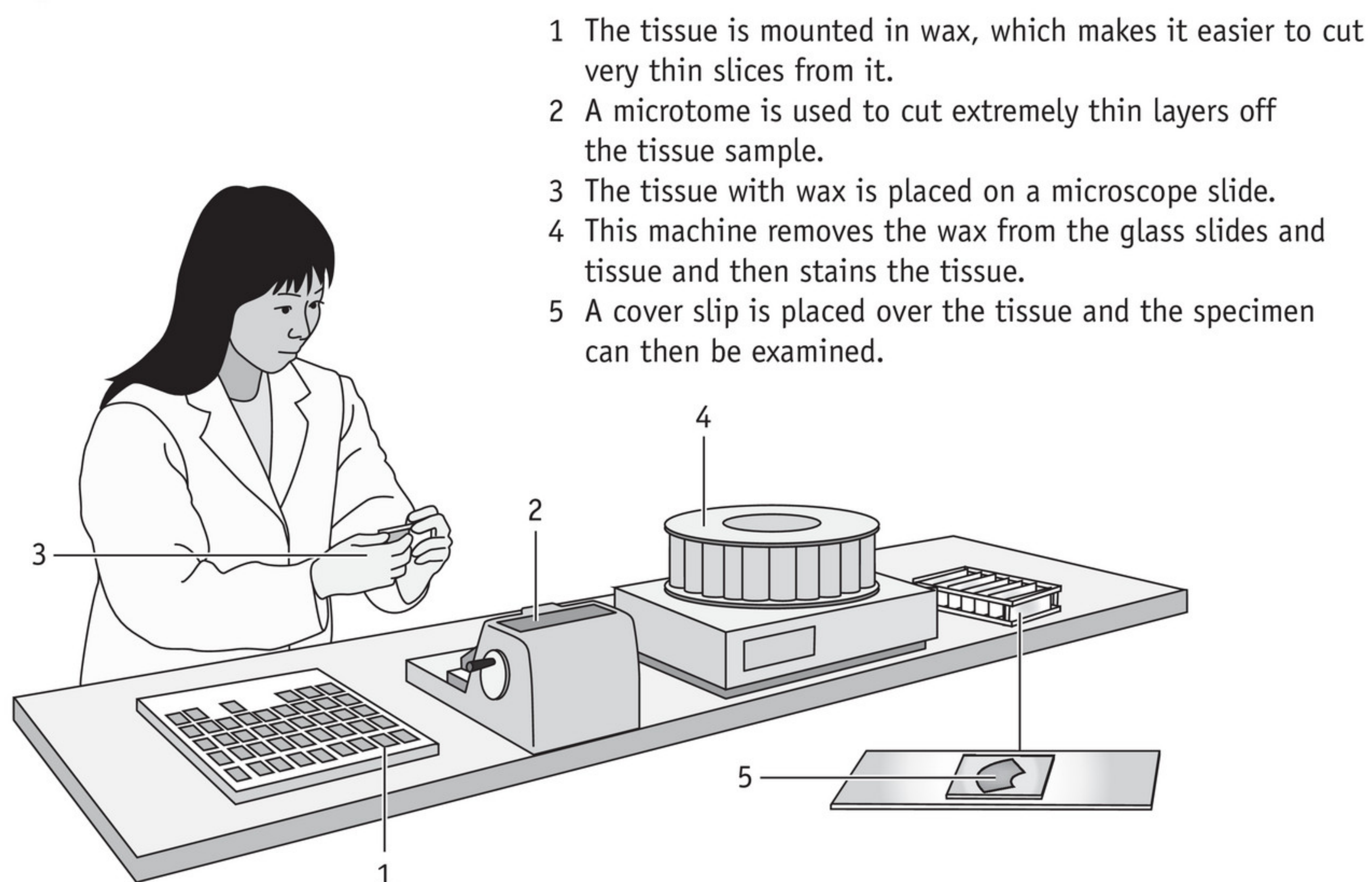
EXERCISE

4

In a pathology laboratory, a lab worker makes specimens from patients' tissues or cells (see figure 12).

- a Why are thin slices made of the tissue?
- b What is the purpose of the staining?

fig. 12



Practical activities

1

FOCUSING AT THE LOWEST MAGNIFICATION

► Basics 1 | ► Learning objective 2.O.16 | ► Learning how to do research 2

 20-30 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be using a microscope to examine a specimen. You make a drawing of this.

WHAT DO YOU NEED?

- ☐ a microscope
- ☐ a ready-made specimen
- ☐ drawing materials

WORKING METHOD

- Place the microscope in front of you with the arm facing you.
- Check that the tube contains the eyepiece lens with a magnification of 10 $\times$.
- Check that the diaphragm is opened as wide as it will go.
- Check that you are using the smallest objective lens (4 $\times$).
- Examine the specimen. Use figure 6 from 'Learning how to do research'. If you don't see anything, look at figure 8 from 'Learning how to do research'.
- Moving the specimen about to find a part of the object that looks clear.
- Make a true-to-life drawing of the object.
- If you recognise parts, write down their names.
- Write down what the object is and the magnification used under the drawing.

2

FOCUSING AT A HIGHER MAGNIFICATION.

► Basics 1 | ► Learning objective 2.O.16 | ► Learning how to do research 2

 10-15 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will take a look at a specimen at a higher magnification.

WHAT DO YOU NEED?

☐ the microscope, still focused from practical activity 1

WORKING METHOD

- Check that the microscope is properly focused at the lowest magnification.
- Figure 7 in 'Learning how to do research' shows what you have to do to get it focused at a greater magnification. You have to do this when you change from 40× magnification to 100×. You have to do this again when you change from 100× magnification to 400×.
- Look at part of the object using a magnification of 400×.
- Tidy the microscope away. First rotate the revolving nosepiece so that the smallest objective lens is underneath (or a part of the revolving nosepiece that does not have an objective lens attached). Then lower the stage (or raise the tube) and remove the specimen. Always hold onto the microscope by the arm and support the microscope with your other hand.

3

THE IMAGE UNDER THE MICROSCOPE

► Basics 1 | ► Learning objective 2.O.16 | ► Learning how to do research 2

 20-25 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be investigating the image through the microscope. You will be doing that by looking at letters.

WHAT DO YOU NEED?

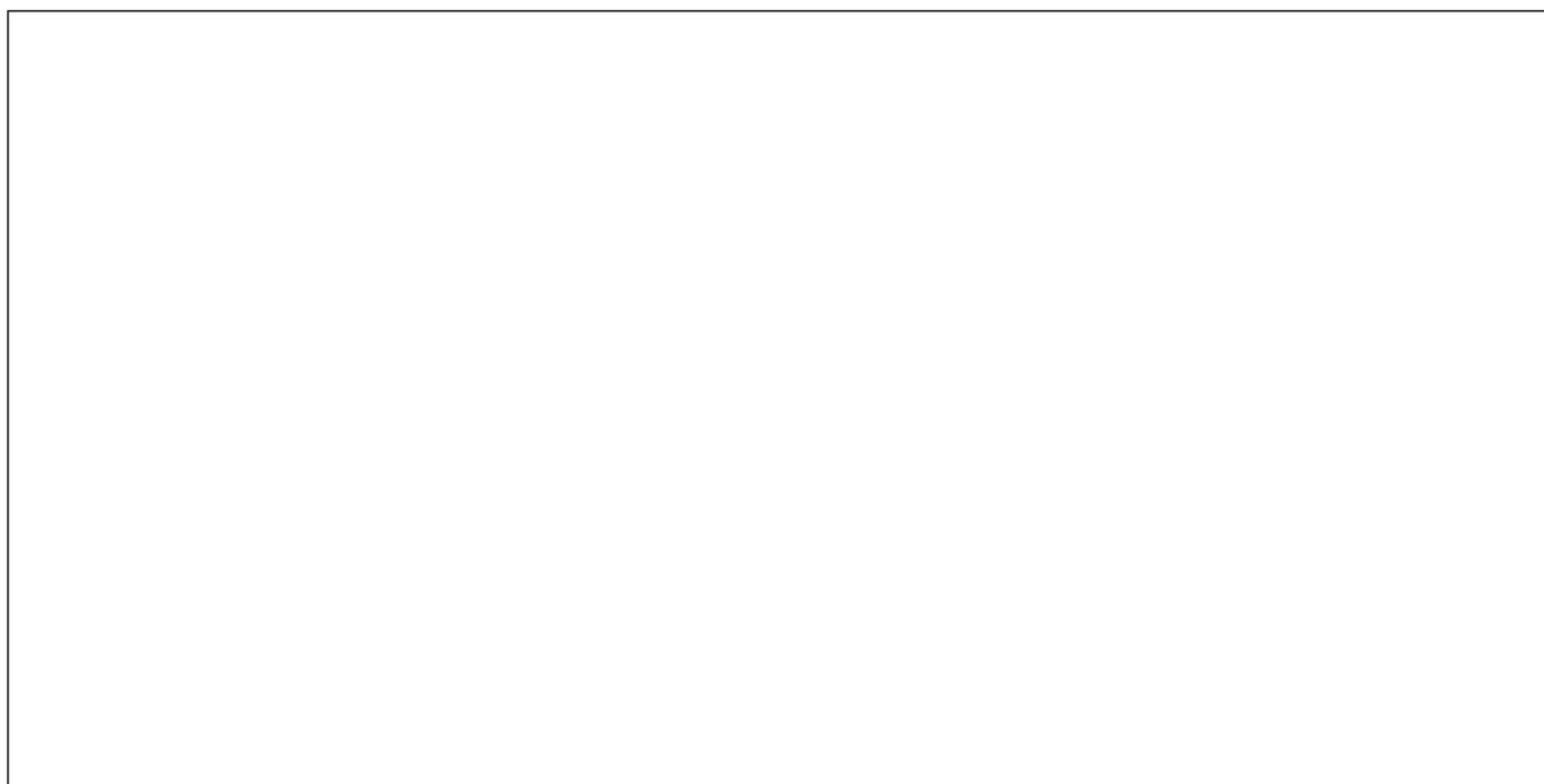
- ☐ a microscope
- ☐ a newspaper
- ☐ scissors
- ☐ drawing materials

WORKING METHOD

- Cut out a piece of text in very small print from the newspaper. The cutting should be about 4 cm wide and 2 cm high.
- Place this piece of paper over the opening in the microscope stage. Place the cutting so that the bottoms of the letters are facing you. You don't need to fix the cutting into place with the stage clips (see figure 1).
- Examine the letters using the lowest magnification.
- Look for a letter 'e' in the text.
- Make a true-to-life drawing of the letter 'e' as it appears through the microscope. Stick the newspaper cutting in next to your drawing and underline a letter 'e'.

fig. 1 Looking at letters through the microscope.





4

SHARPNESS OF THE IMAGE THROUGH THE MICROSCOPE

► Basics 1 | ► Learning objective 2.O.16 | ► Learning how to do research 2

 20-30 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be examining and comparing hairs. You will be examining which parts of a specimen you can see in sharp focus.

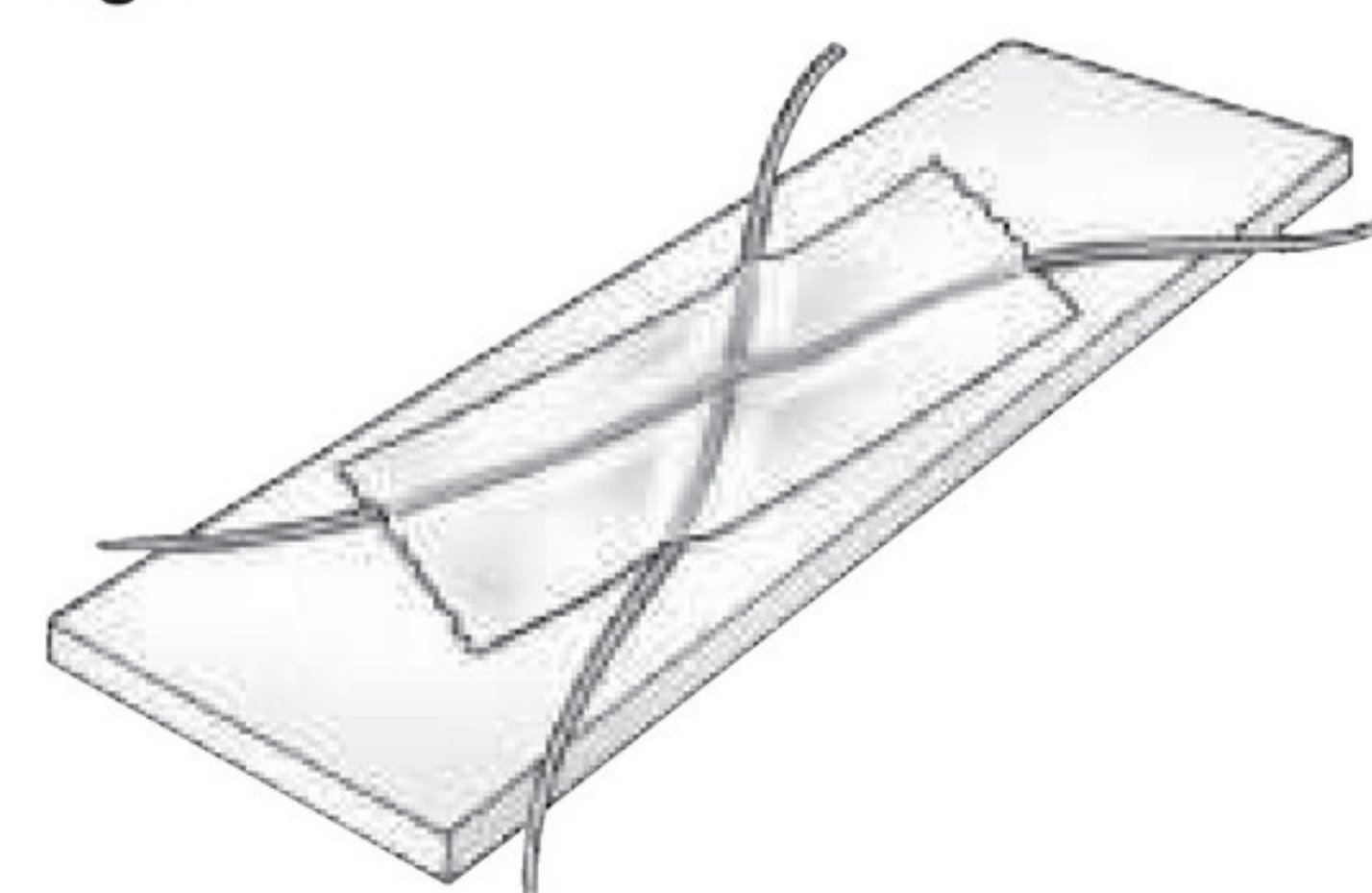
WHAT DO YOU NEED?

- ☐ a microscope
- ☐ scissors
- ☐ a slide
- ☐ sticky tape

WORKING METHOD

- Cut a piece off a single hair on your head. Ask the person next to you for a piece of a single hair from their head too.
- Lay one hair on top of the other to make an X and press them onto the sticky side of a piece of adhesive tape. Place the sticky tape on a slide (see figure 2).
- Examine the hairs under the microscope at a magnification of 100 $\times$. Find the point at which the hairs cross.
- Examine the hairs at a magnification of 400 $\times$. Compare the thickness of the two hairs.

fig. 2



EXERCISE

1

You want to compare the thickness of the two hairs.

- a Can you see both the hairs in focus at the same time where they cross? *yes / no*
- b Which knob do you have to turn to get each of the two hairs alternately in clear focus: the large knob or the small knob? *the large knob / the small knob*
- c Which of the two of you has the thicker hair?
- d If you examine a cell through the microscope, can you see all parts of that cell in focus at the same time? *yes / no*

5

ROOT HAIRS

▶ Basics 2 | ▶ Learning objectives 2.2.3 and 1.0.20

 15-20 minutes**WHAT ARE YOU GOING TO DO?**

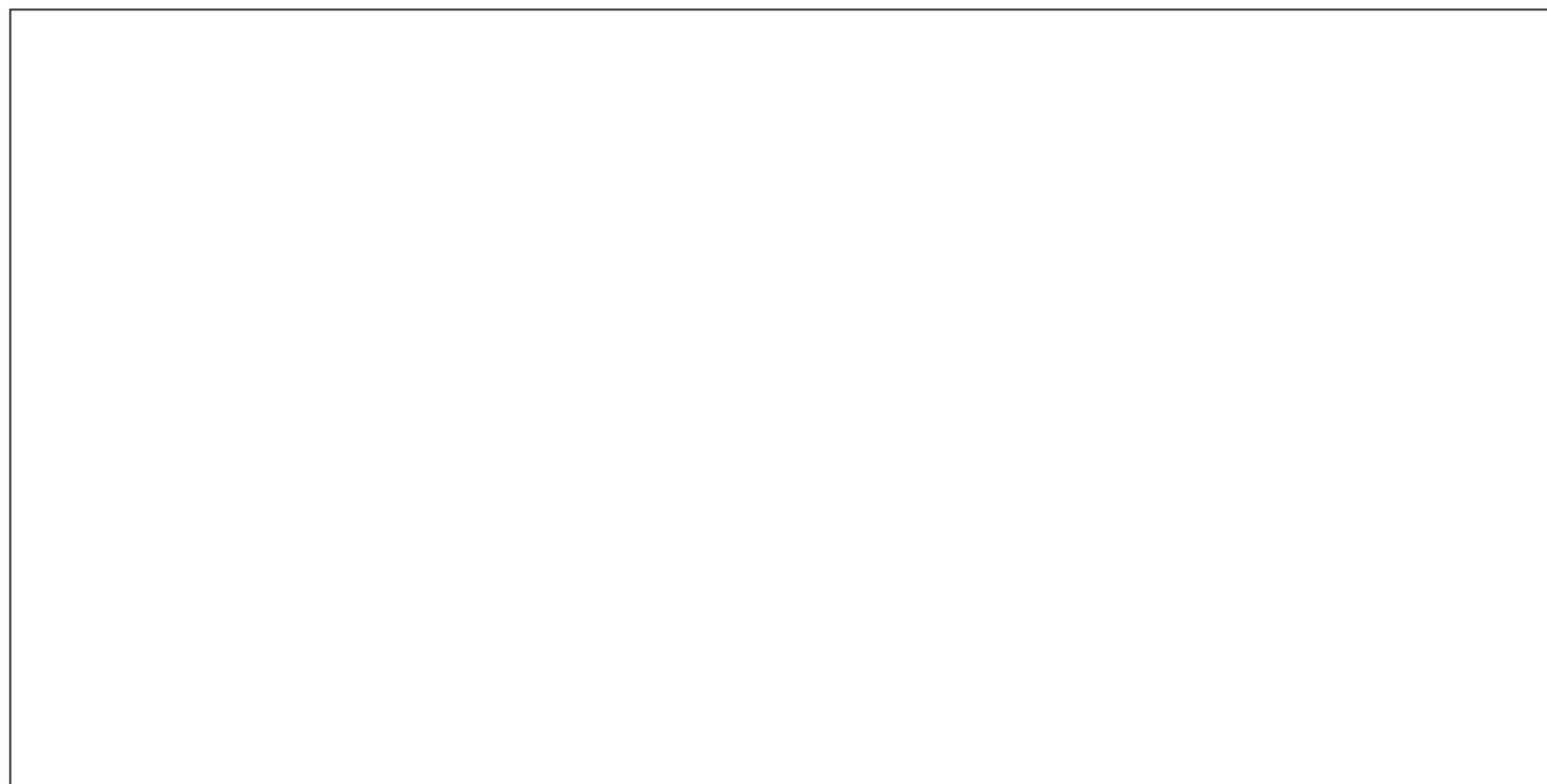
Your teacher has laid out seeds to germinate on moist filter paper. Seedlings have grown from these seeds. On many seedlings, you can see a ‘furry’ part on the root. In this practical activity, you will be examining this and making a drawing of it.

WHAT DO YOU NEED?

- ☐ seedlings (cress, for example)
- ☐ a magnifying glass
- ☐ drawing materials

WORKING METHOD

- Carefully separate the root of a seedling from the filter paper. Try to do as little damage as possible to the ‘furry’ part as you do this.
- Use a magnifying glass to examine the furry part of the root. You will then be able to see the root hairs.
- Make a true-to-life drawing of the root with the root hairs. Label the following parts: *root – root hairs*. Remember the drawing rules!



6

THE STRUCTURE OF LEAVES

▶ Basics 2 | ▶ Learning objectives 2.2.3 and 1.0.20

 10-15 minutes**WHAT ARE YOU GOING TO DO?**

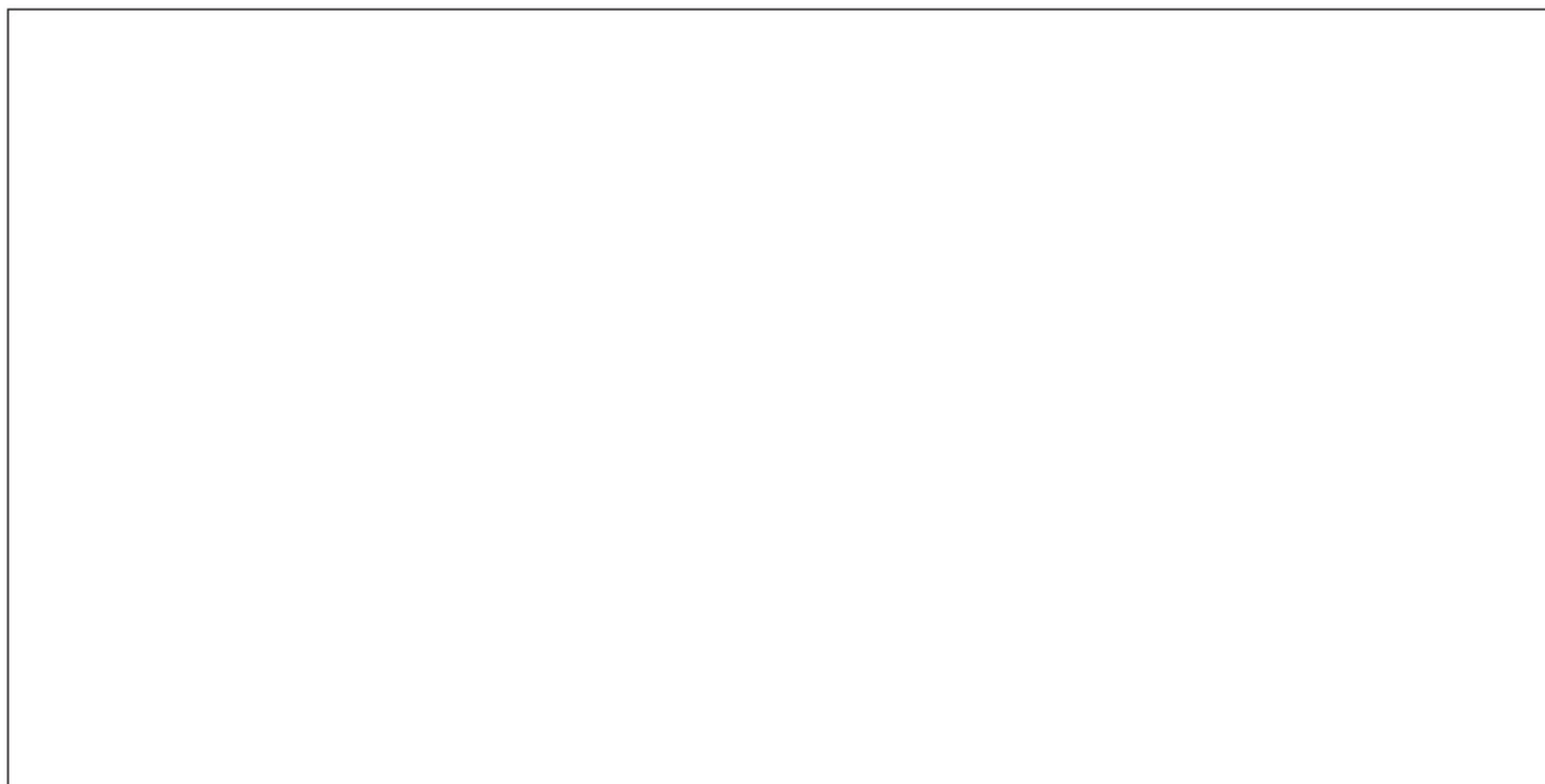
In this practical activity, you will draw the parts of a leaf.

WHAT DO YOU NEED?

- ☐ a complete leaf from a birch, a beech or an oak
- ☐ drawing materials

WORKING METHOD

If you hold the leaf up against the light, you can see the veins clearly. Make a true-to-life drawing of the leaf. Label the following parts: *lamina* – *blade* – *leaf stalk* – *main vein* – *lateral vein*. Remember the drawing rules!

**7****VASCULAR BUNDLES**

► Basics 2 | ► Learning objectives 2.2.4 and 1.0.20

 **15-20 minutes**

WHAT ARE YOU GOING TO DO?

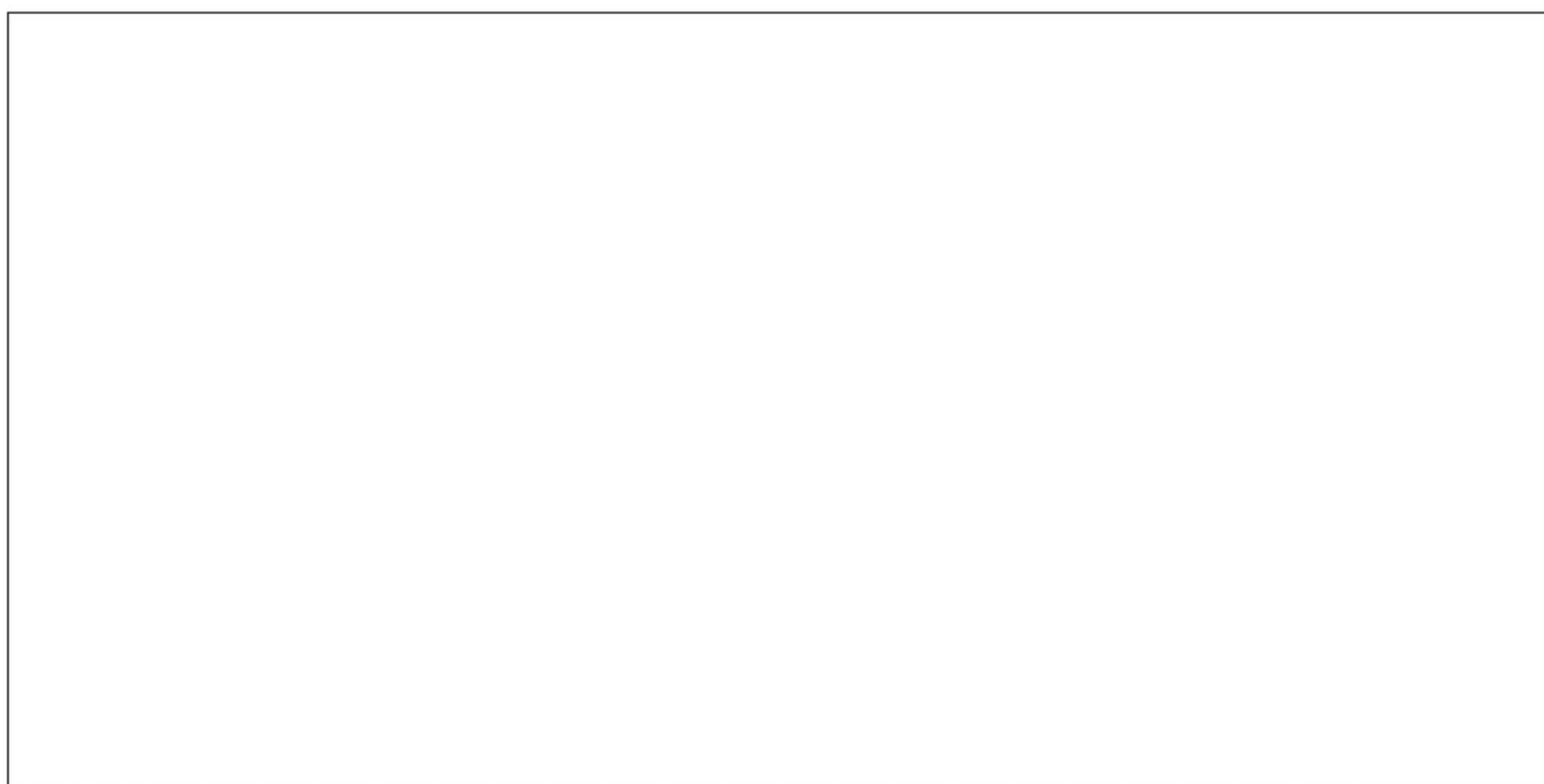
In this practical activity, you will be examining vascular bundles. You make a drawing of this.

WHAT DO YOU NEED?

- ☐ a piece of stem that has been standing in ink for some time (for example a piece of celery stem)
- ☐ a knife
- ☐ a magnifying glass
- ☐ drawing materials

WORKING METHOD

- Make a horizontal cross-section of the stem with the knife.
- Make a true-to-life drawing of the cross section of the stem. Label the vessels in the drawing. Remember the drawing rules!



8

THE SKIN OF AN ONION

► Basics 3 | ► Learning objectives 2.O.16 and 2.O.17 | ► Learning how to do research 2 and 3

 30-40 minutes

WHAT ARE YOU GOING TO DO?

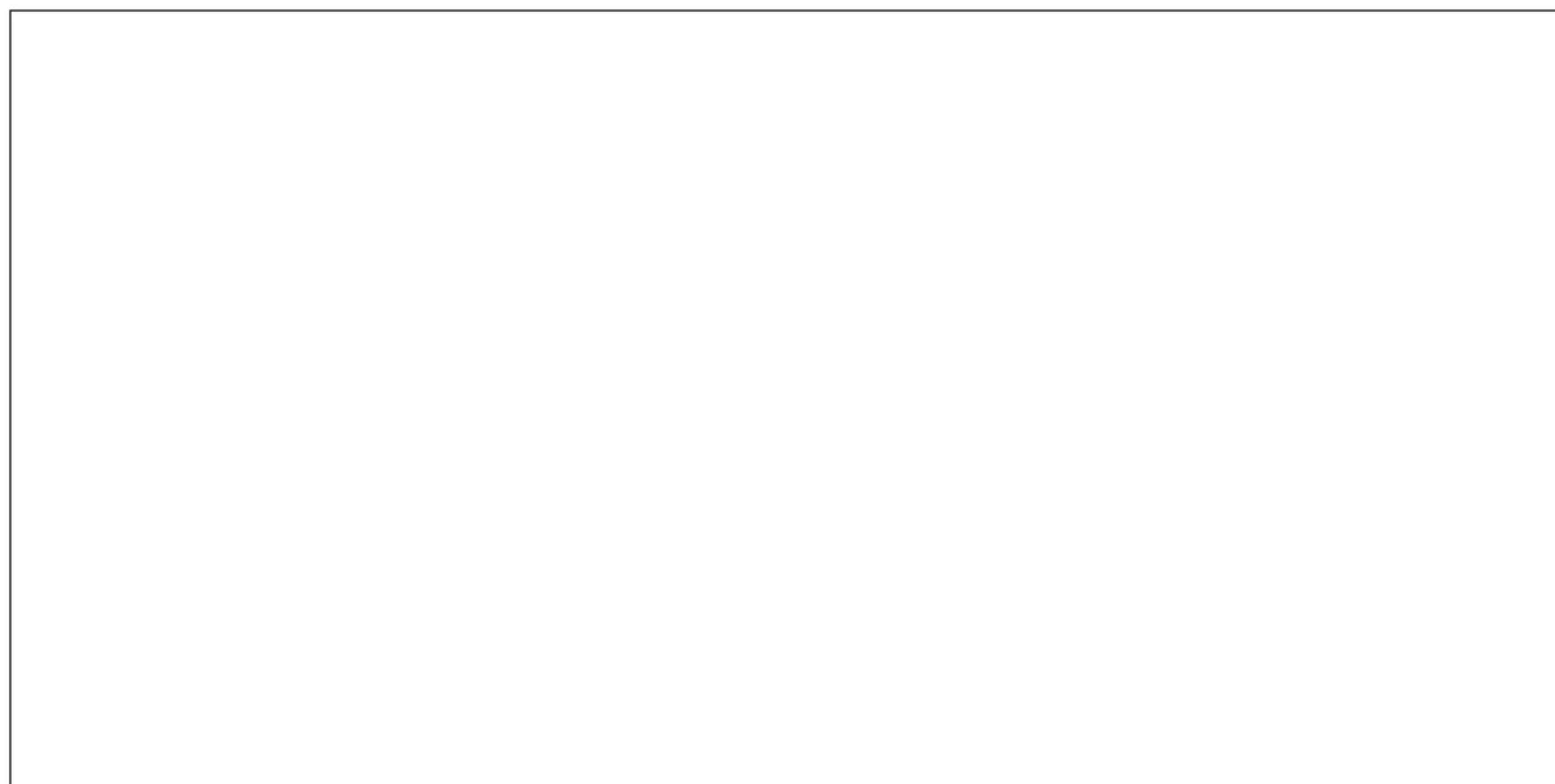
In this practical activity, you will be making a specimen from the skin of an onion. Then you are going to examine the specimen and make a drawing of it.

WHAT DO YOU NEED?

- ☐ a microscope
- ☐ a piece of an onion
- ☐ preparation materials
- ☐ dye solution
- ☐ drawing materials

WORKING METHOD

- Take a clean slide and squeeze a drop of the stain onto it.
- Take the piece of onion and pull the food storage leaves apart. You will find a thin skin on the inside of the food storage leaf. You can use tweezers to pull it off.
- Figure 10 in 'Learning how to do research' shows what you have to do next to make a specimen from the skin of an onion.
- Examine the specimen under the microscope at a magnification of 100×. Follow the steps in figures 6 and 7 from 'Learning how to do research'.
- If you have a good specimen, you will be able to see the cells of the skin of the food storage leaf. Compare your specimen against figure 11 in 'Learning how to do research'. Make a new specimen if necessary.
- Examine how the cells are connected to one another.
- Make a true-to-life drawing of three adjoining cells.



9

THE EPIDERMIS

► Basics 3 | ► Learning objectives 2.3.6, 2.0.16 and 2.0.17 | ► Learning how to do research 2 and 3

 30-40 minutes

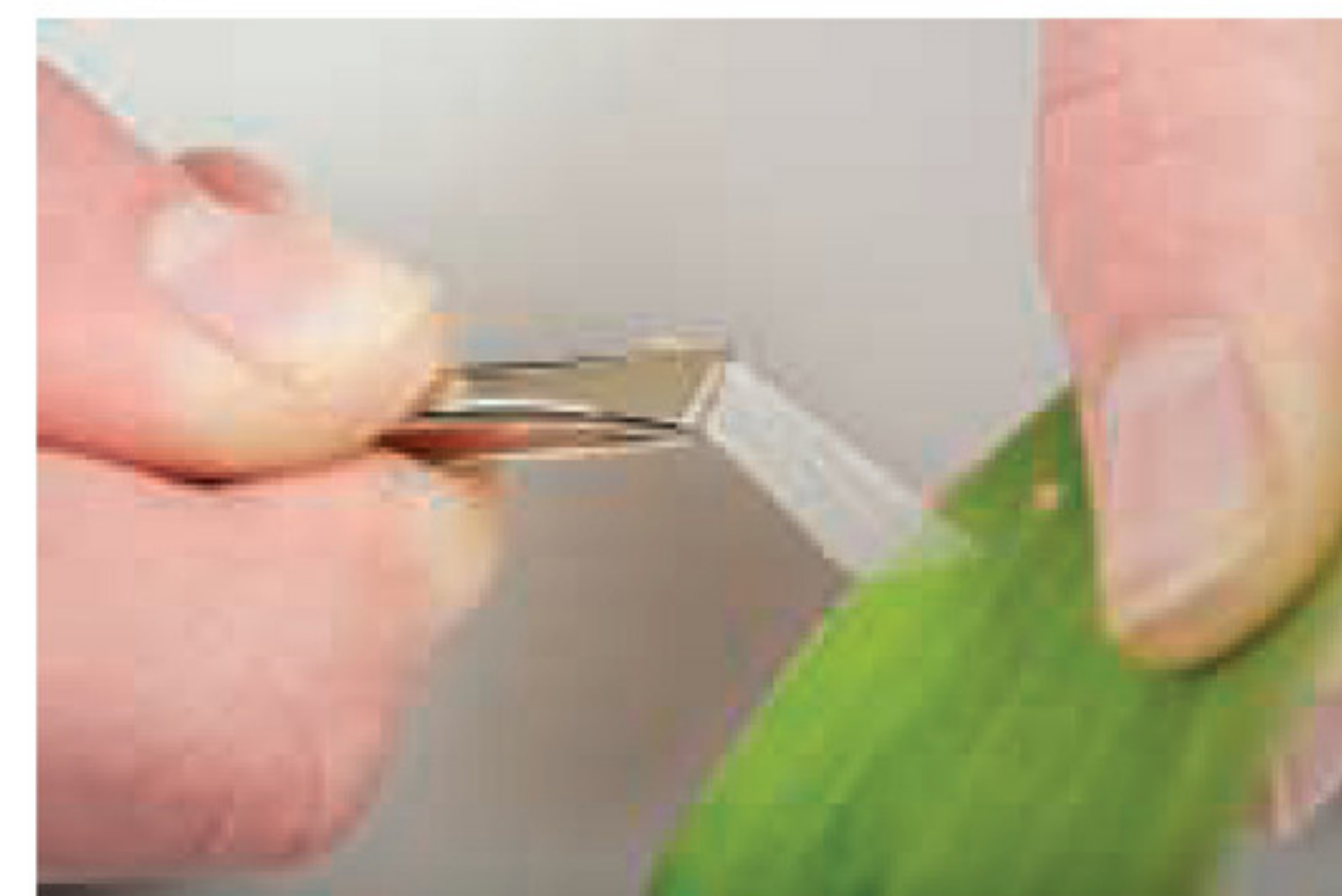
WHAT ARE YOU GOING TO DO?

In this practical activity, you will examine the epidermis and stomata of a leaf. Suitable plants are tulips, lilies and *Tradescantia* (spiderwort).

WHAT DO YOU NEED?

- ☐ a microscope
- ☐ a leaf from a plant
- ☐ preparation materials
- ☐ drawing materials

fig. 3

**WORKING METHOD**

- Fold the leaf in half and carefully pull the two halves apart along the fold. You will then see a transparent skin (see figure 3). This is the epidermis. Cut off a small piece of this skin. (Some leaves don't tear when you fold them. In that case, you can cut into the leaf a little bit with the blade and then tear it.)
- Make a specimen from this piece of epidermis (see figure 10 in 'Learning how to do research'). Use a drop of water instead of a drop of stain solution.
- Examine the specimen under the microscope at a magnification of $40\times$. Find a section where the cells are clearly visible. Examine the specimen using a magnification of $100\times$ and look for a section with a stoma.
- Make a drawing of a stoma with some epidermal cells. Label the following parts:
stoma – epidermal cell.

10

CELLS FROM YOUR CHEEK LINING

▶ Basics 4 | ▶ Learning objectives 2.4.7, 2.0.16 and 2.0.17 | ▶ Learning how to do research 2 and 3

 30-40 minutes**WHAT ARE YOU GOING TO DO?**

In this practical activity, you will be making a specimen with cells from your own cheek lining. You will be examining them and drawing them.

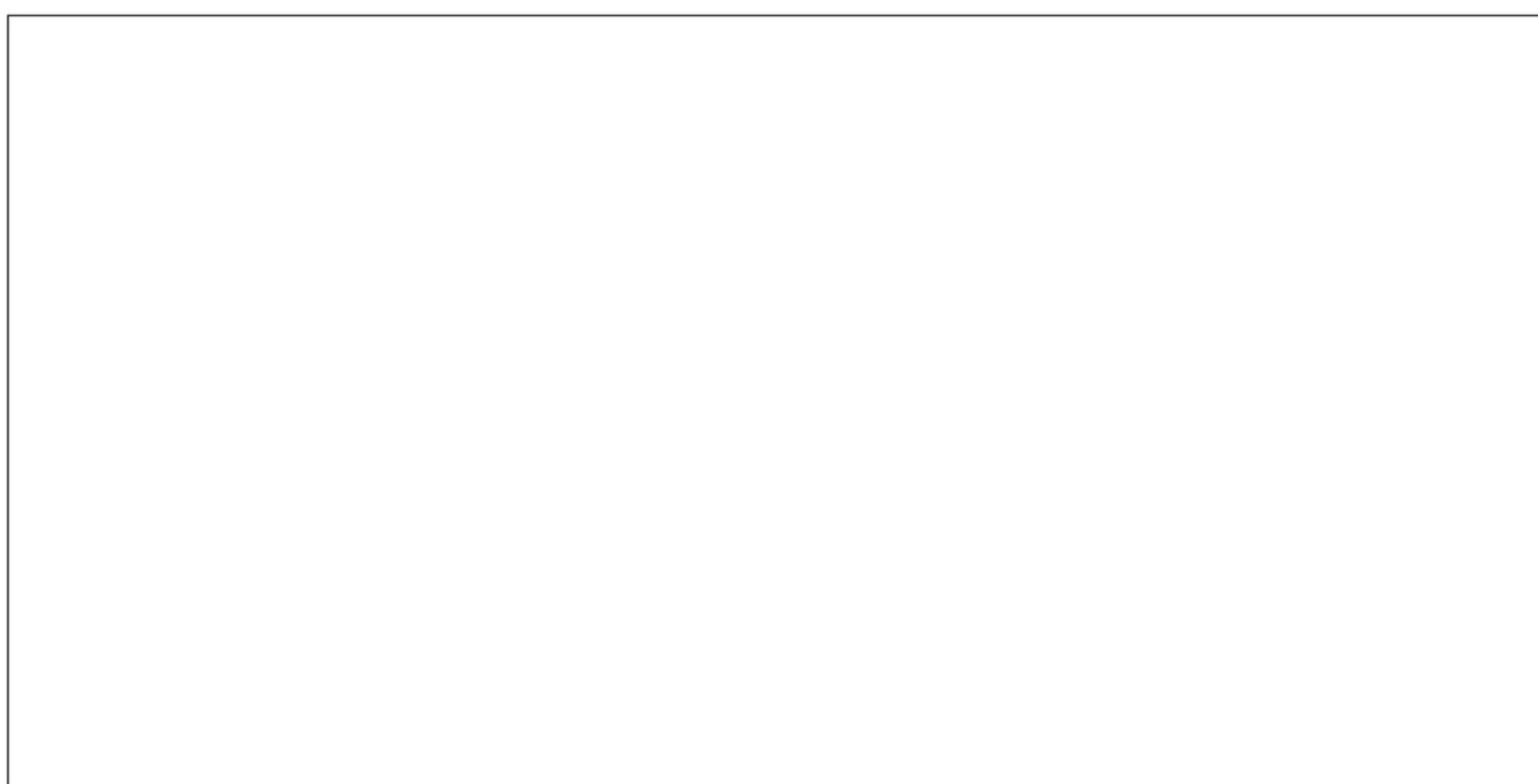
WHAT DO YOU NEED?

- ☐ a microscope
- ☐ a stirrer or wooden spatula
- ☐ preparation materials
- ☐ dye solution
- ☐ drawing materials

WORKING METHOD

- Use the stirrer to scrape along the inside of your cheek (see figure 4). You could also use your fingernail or a wooden spatula.
- Transfer the scraping to a clean slide and add a drop of the stain (dye solution). Put a coverslip over the specimen. Use figure 10 from 'Learning how to do research'.
- Examine the specimen under the microscope at a magnification of 100×. Follow the steps in figures 6 and 7 from 'Learning how to do research'. You will see loose cells and cells that are attached to each other or overlap.
- Examine one cell at a magnification of 400×.
- Make a true-to-life drawing of the cell. Label the following parts: *nucleus* – *cell membrane* – *cytoplasm*.
- Clean the materials you have used and dry them with a tissue.

fig. 4



11

A WATERWEED LEAF

► Basics 4 | ► Learning objectives 2.4.8, 2.0.16 and 2.0.17 | ► Learning how to do research 2 and 3

 25-35 minutes**WHAT ARE YOU GOING TO DO?**

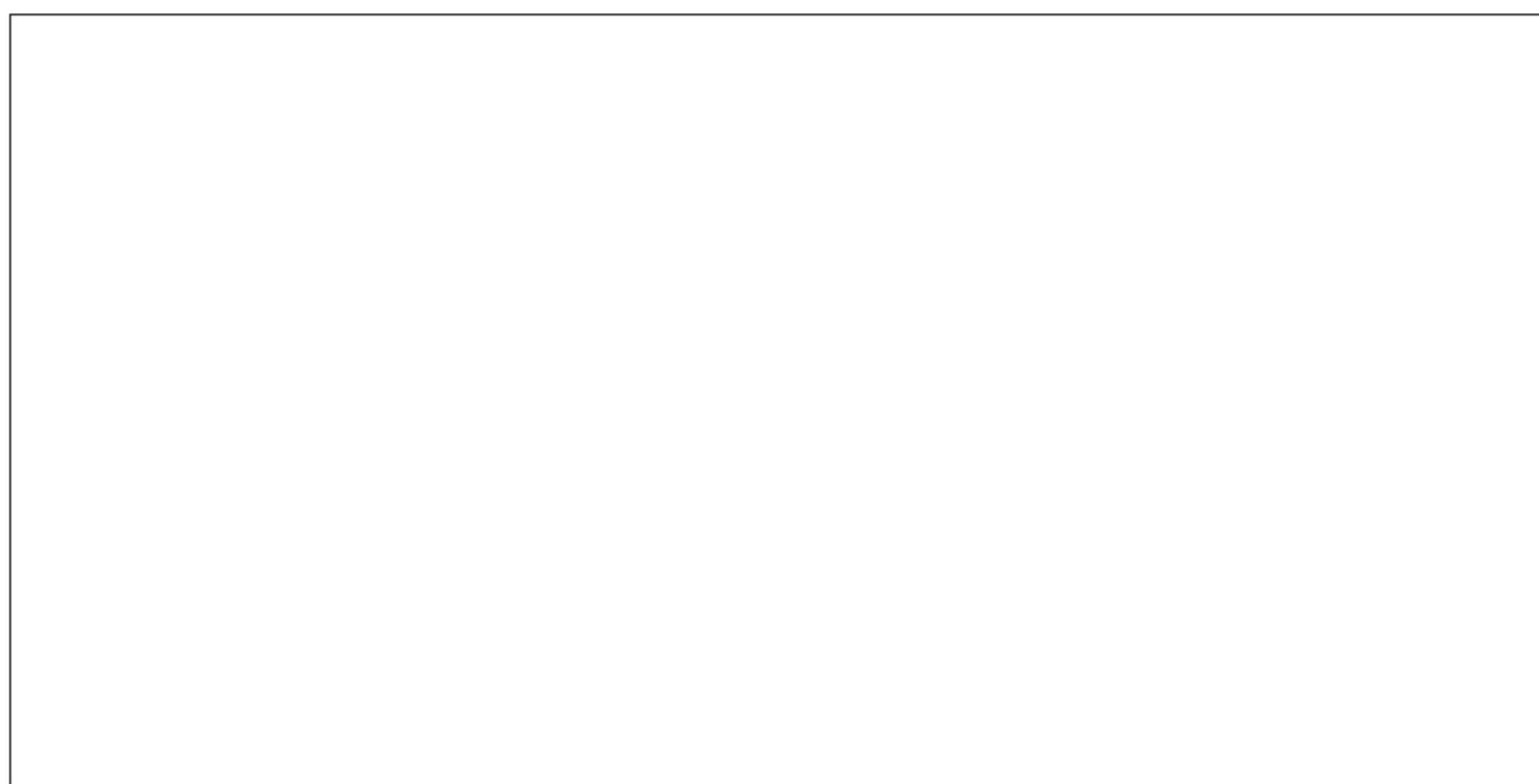
In this practical activity, you will be making a specimen with cells from the waterweed plant. You will be examining it through a microscope and making a drawing of it.

WHAT DO YOU NEED?

- ☐ a microscope
- ☐ a stalk of waterweed with some leaves
- ☐ water
- ☐ preparation materials
- ☐ drawing materials

WORKING METHOD

- Take a slide and put a drop of water onto it.
- Use the tweezers to pull off a leaf of waterweed and put it in the drop of water. Complete the preparation of the specimen.
- Examine the specimen under the microscope at a magnification of 100×. You will see two layers of cells on top of one another. Focus on one of the two layers.
- Set the diaphragm open as far as it will go and examine the specimen at a magnification of 400×. Adjust the focus to be sharp enough for you to see the chloroplasts in an individual cell (see figure 3 in Basics 4). The chloroplasts are in the cytoplasm. The vacuole is in the middle of the cell. The nucleus is colourless and you can't normally see it. Sometimes you can see the chloroplasts moving around with the cytoplasm.
- Make a true-to-life drawing of one cell with its cell wall. Label the following parts: *chloroplasts – cell wall – cytoplasm – vacuole*.
- Throw away the leaf and the liquid.



12

CHROMOPLASTS

► Basics 4 | ► Learning objectives 2.4.8, 2.0.16 and 2.0.17 | ► Learning how to do research 2 and 3

 25-35 minutes**WHAT ARE YOU GOING TO DO?**

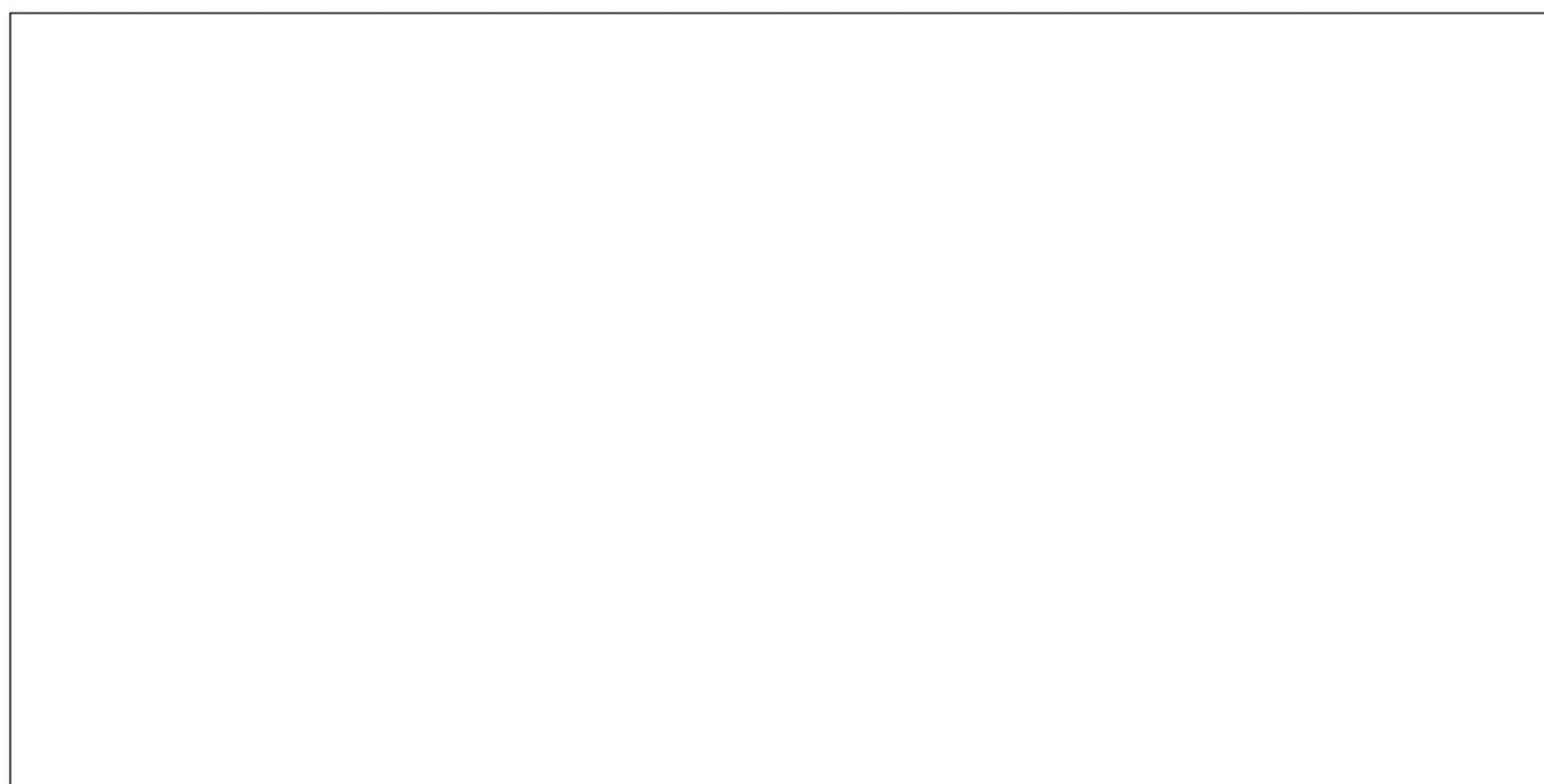
In this practical activity, you will be making a specimen with cells from a tomato. You are going to examine the chromoplasts in your specimen and make a drawing of them.

WHAT DO YOU NEED?

- ☐ a microscope
- ☐ a cherry tomato or snack tomato
- ☐ water
- ☐ preparation materials
- ☐ drawing materials

WORKING METHOD

- Use the blade to cut off a thin piece of the tomato's skin and carefully scrape some of the tissue away from just beneath the skin.
- Put the scraping in a drop of water on a slide and carefully place a coverslip on top. Then tap the coverslip with the handle of a mounted needle. That will make the tissue spread out a little.
- Using a magnification of 40×, look for some loose cells.
- Examine these cells at a magnification of 400×. You will see small red chromoplasts in the cells.
- Make a drawing of one cell with its cell wall. Label the following parts: *cell wall* – *chromoplast*.



13

AMYLOPLASTS

► Basics 4 | ► Learning objectives 2.4.8, 2.0.16 and 2.0.17 | ► Learning how to do research 2 and 3

 25-35 minutes**WHAT ARE YOU GOING TO DO?**

In this practical activity, you will be making a specimen with cells from a potato. You are going to examine the amyloplasts in your specimen and make a drawing of them.

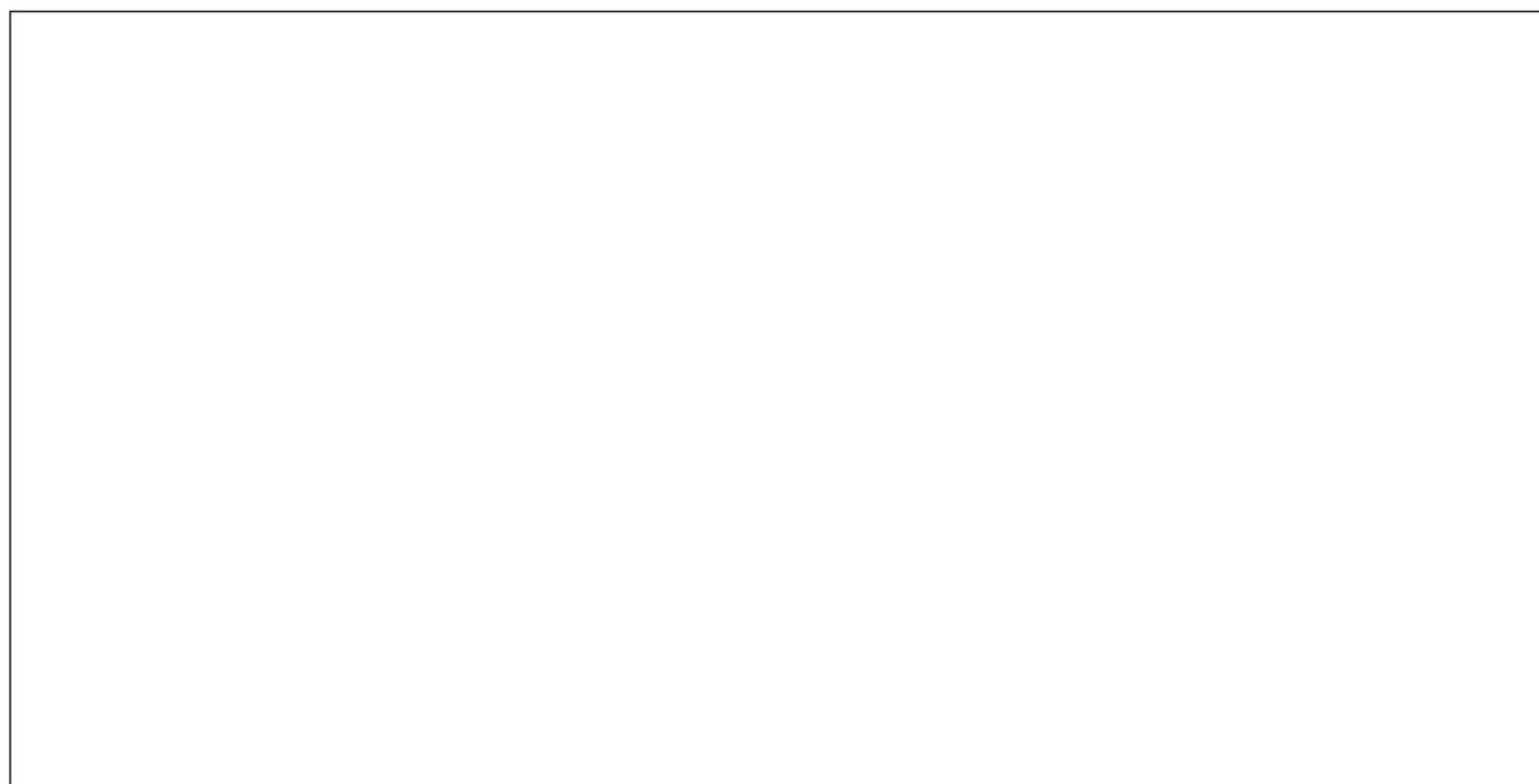
WHAT DO YOU NEED?

- ☐ a microscope
- ☐ a potato
- ☐ preparation materials
- ☐ iodine solution (diluted) in a bottle with a pipette
- ☐ drawing materials

fig. 5

**WORKING METHOD**

- Cut the potato in two. Use the blade to scrape along the cut surface (see figure 5). You then get some scrapings on the blade. All you need is a tiny bit of scrapings.
- Use the scrapings to make a specimen in a drop of iodine solution. The iodine solution stains the amyloplasts bluish purple.
- Examine the specimen under the microscope at a magnification of 100×. You will see round and oval amyloplasts (see figure 5 in Basics 4). You may also see pieces of cell wall. You destroyed the cell walls by scraping with the blade.
- Make a true-to-life drawing of a few amyloplasts.



14

CHROMOSOMES IN CELLS THAT ARE DIVIDING

► Basics 5 | ► Learning objectives 2.5.9 and 2.0.16 | ► Learning how to do research 2

 15-20 minutes

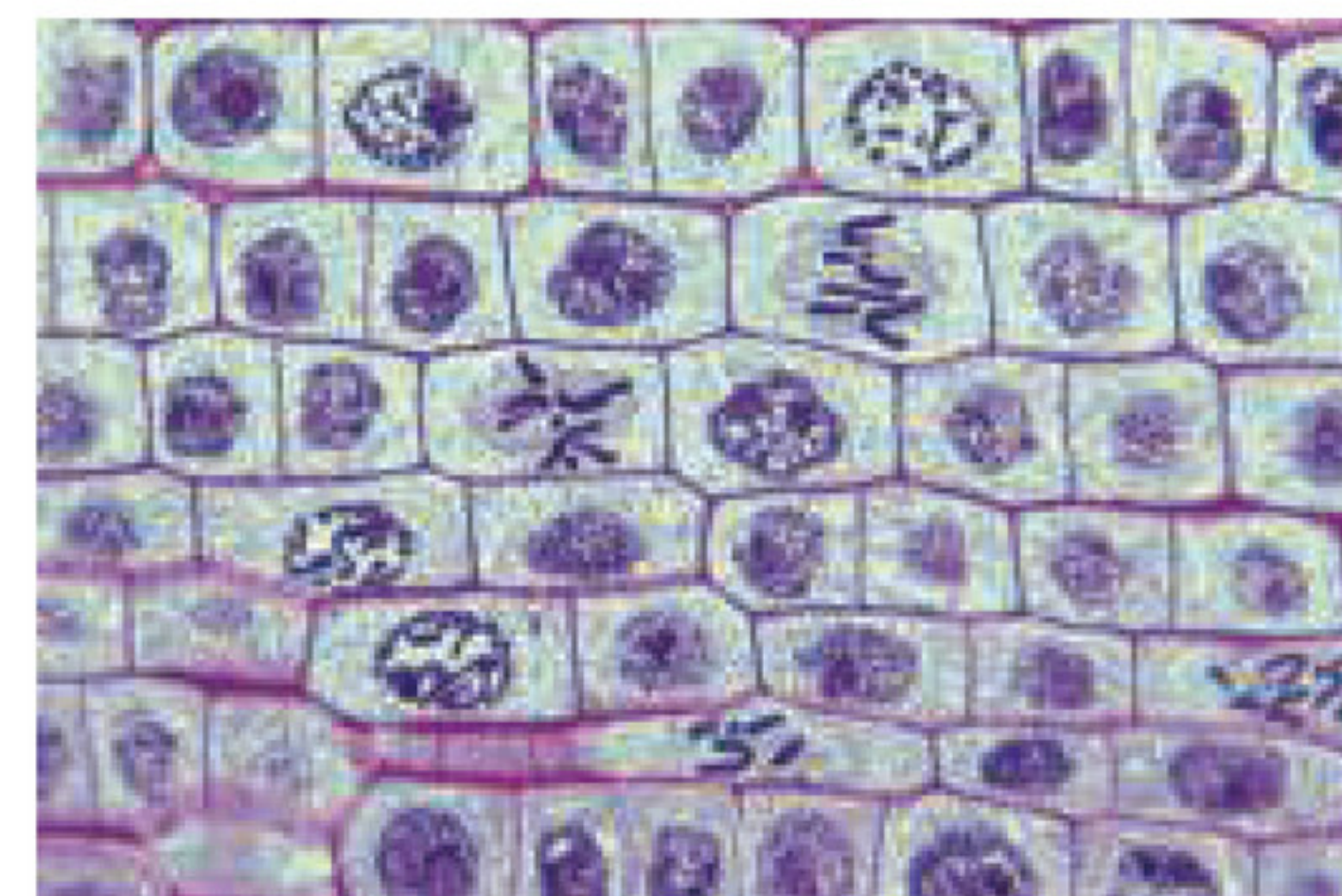
WHAT ARE YOU GOING TO DO?

In this practical activity, you will be examining the chromosomes in cells that are dividing. You will be using a specimen of a young onion root.

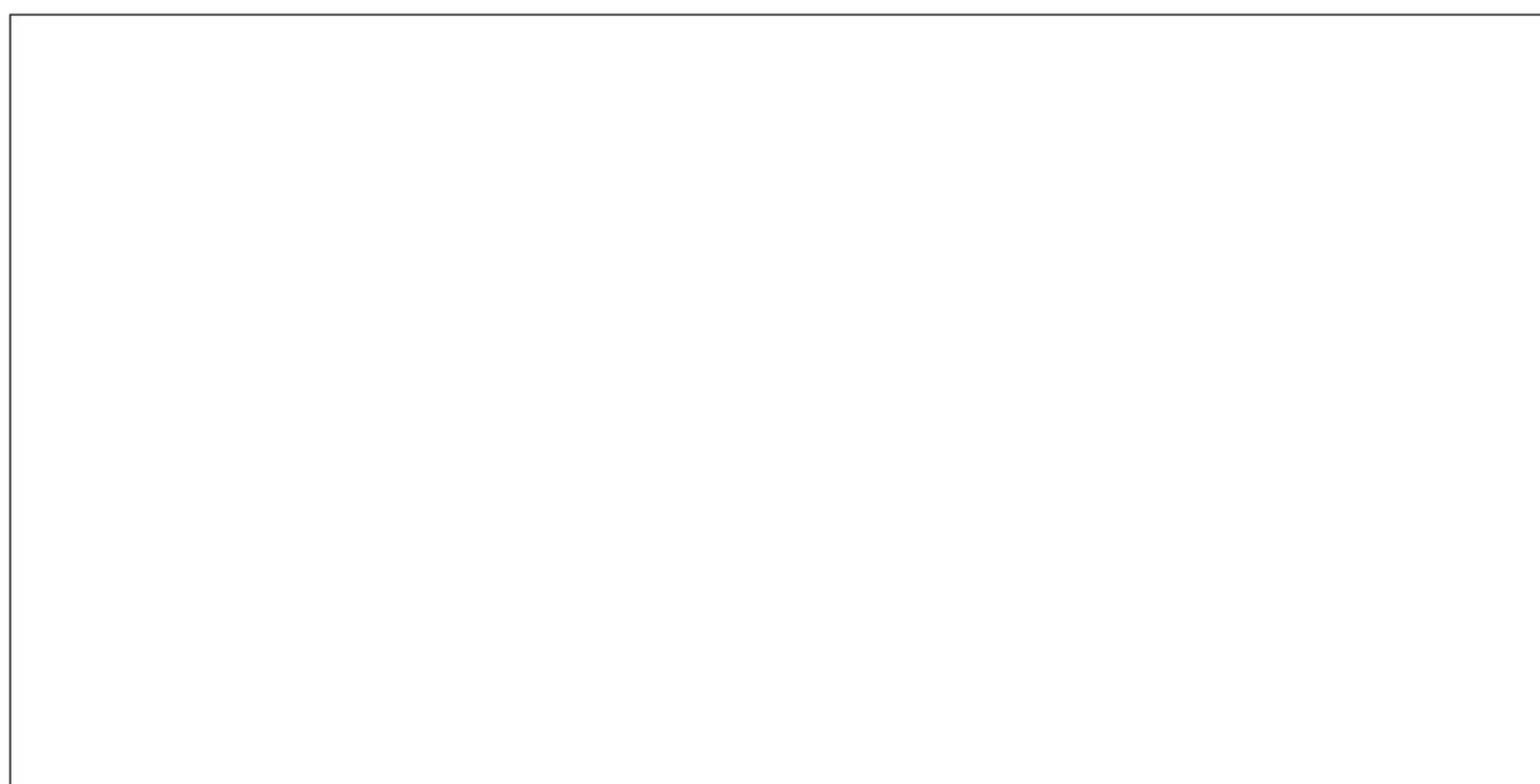
WHAT DO YOU NEED?

- ☐ a microscope
- ☐ a ready-made specimen with the longitudinal section of a young onion root
- ☐ drawing materials

fig. 6 Cells in the root tip of an onion.

**WORKING METHOD**

- Examine the slide at a magnification of 100×. The root tip contains cells that are dividing. The chromosomes are visible in these cells. These cells show the various phases of cell division (see figure 6).
- Find a cell where the chromosomes are visible. Examine this cell using a magnification of 400×.
- Make a drawing of this cell. Label the chromosomes.



15

THE AMOEBA

► Extra 7 | ► Learning objectives 2.7.13 and 2.0.16 | ► Learning how to do research 2

 20-25 minutes

WHAT ARE YOU GOING TO DO?

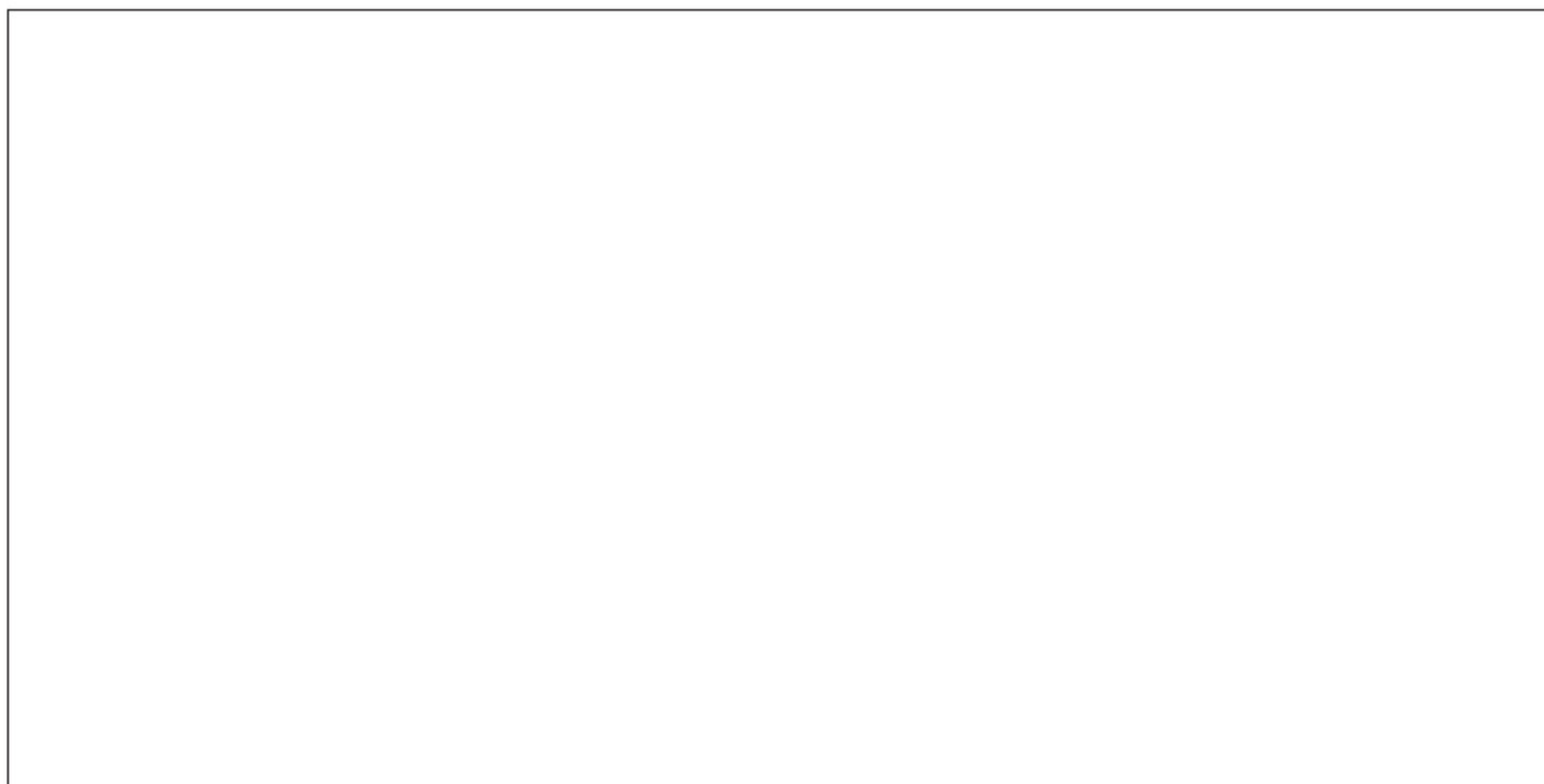
In this practical activity, you will be using a microscope to examine an amoeba. You make a drawing of this.

WHAT DO YOU NEED?

- ☐ a ready-made specimen slide of an amoeba
- ☐ a microscope
- ☐ drawing materials

WORKING METHOD

- Examine the slide at a magnification of 100 $\times$. Find an amoeba in the sample.
- Examine the amoeba at a magnification of 400 $\times$.
- Make a drawing of the amoeba. Label the following parts: *nucleus* – *cell membrane* – *cytoplasm* – *pseudopod*.

**16****PARAMECIA**

► Extra 7 | ► Learning objectives 2.7.13, 2.O.16 and 2.O.17 | ► Learning how to do research 2 and 3

 **20-25 minutes**

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be using a microscope to examine a paramecium.

WHAT DO YOU NEED?

- ☐ a culture containing paramecia (see figure 7)
- ☐ a microscope
- ☐ preparation materials
- ☐ glycerine or methylcellulose solution (wallpaper paste)

WORKING METHOD

- There is a membrane on top of the water with the paramecium culture. Using a pipette, draw up a droplet of water carefully from just under the membrane (see figure 7).
- Make a specimen from the droplet.
- Examine the slide at a magnification of 100 $\times$. You will almost certainly be able to find some paramecia. They move quickly through the field of view.
- Add a drop of glycerine or methylcellulose solution to the droplet containing the paramecia. This will make the paramecia move more slowly.
- Examine one paramecium at a magnification of 400 $\times$.

fig. 7 Culture of paramecia.



17

ISOLATING DNA

▶ Extra 8 | ▶ Learning objective 2.8.14

⌚ 40-50 minutes

WHAT ARE YOU GOING TO DO?

Before you can make a DNA profile, you first need to isolate the DNA from cells. In this practical activity, you will be isolating some of your own DNA.

WHAT DO YOU NEED?

- ☐ a test tube
- ☐ a glass beaker (100 mL)
- ☐ a 10 mL syringe (or measuring cylinder)
- ☐ a 1 mL syringe
- ☐ a water bath at 60 °C
- ☐ ORS (this is a mixture containing salt and sugar. It is used when someone becomes dehydrated, for example because of diarrhoea.)
- ☐ washing-up liquid
- ☐ cold alcohol
- ☐ gloves

WORKING METHOD

- Make the ORS by dissolving the contents of the sachet according to the instructions.
- Chew on your cheeks gently for about half a minute. Then put about 10 mL ORS in your mouth and flush it around. Spit the ORS (with cheek lining cells) back into the glass beaker.
- Add 1 mL of washing-up liquid to the glass beaker and carefully swirl around the liquid in the glass beaker. (It must not start to foam. The washing-up liquid breaks open the cells, releasing the DNA into the solution.)
- Take 6 mL from the solution and put it in a test tube. Place the test tube in a water bath at 60°C.
- After 20 minutes, take the test tube out of the water bath and carefully add 6 mL of cold alcohol. Use gloves for this. If you get the cold alcohol on your skin, you will get a burn.
- After approximately 5 minutes, you will see a white 'band' appear (see figure 8). This is your DNA.

fig. 8



Summary

BASICS 1

ANIMAL ORGANS

1 You can identify the organs in a torso and in a cross-section of the body.

- Organ: a part of an organism that performs a specific function.
 - Examples: stomach, liver, lung, heart, large intestine, kidney, main artery (aorta).
 - The diaphragm divides the human torso into the chest cavity and the abdominal cavity.
- Organs in the chest cavity: oesophagus, spinal column, ribs, lungs, heart and others.
- Organs in the abdominal cavity: oesophagus, spinal column, stomach, liver, small intestine, large intestine, kidneys, main artery (aorta), main vein (vena cava) and others.

2 You can identify the organs in the organ systems of humans and animals.

- Organ system: a group of organs that cooperate and jointly have a specific function.
- The organ systems in humans and other mammals:
 - respiratory system: includes windpipe, bronchi, lungs
 - skeletal system: includes skull, spinal column, ribs, thigh bones
 - circulatory system: includes heart, main artery (aorta), main vein (vena cava)
 - muscular system: includes biceps, abdominal muscles, thigh muscle
 - digestive system: includes oesophagus, stomach, liver, small intestine, large intestine
 - nervous system: includes brain, spinal cord, nerves

BASICS 2

PLANT ORGANS

3 You can describe the structure and function of roots, stems and leaves.

- Structure of roots:
 - tap root (in most plants): grows downwards
 - lateral roots: roots branching off from the tap root
 - root hairs: thin protrusions, often at the ends of roots
- Functions of the roots:
 - taking up water and nutrients (minerals) from the soil
 - keeping the plant firmly anchored in the ground
 - storing food reserves
- Structure of stems:
 - the part between the roots and the leaves
 - in woody plants: stems are rigid due to wood
 - in herbaceous plants: stems are rigid due to water
- Functions of the stems:
 - to transport substances
 - to make the plant more rigid
- Structure of leaves:
 - leaf stalk: attaches a leaf to the stem
 - blade: the flat part of a leaf
 - veins: main veins and lateral veins; the veins consist of vascular bundles
 - lamina: all the material that is between the veins
- The function of leaves:
 - making food for the plant by photosynthesis

4 You can name organ systems in plants and their functions.

- Organ systems in plants:
 - root system: all the roots of a plant
 - vascular system: vessels in vascular bundles running from the roots to the leaves
- The function of the vascular system is transport:
 - transporting water and minerals from the roots to the other parts of the plant
 - transporting glucose from the leaves to the other parts of the plant

BASICS 3

TISSUES**5 You know that an organism consists of cells.**

- All organisms consist of one or more cells.
 - Cells are the building blocks of organisms.
 - Cells are three-dimensional (e.g. shaped like a ball or cube).

6 You can name tissues in humans and plants with their functions.

- Tissue: a group of cells with the same shape and function.
 - Examples in humans: bone tissue, cartilage tissue, muscular tissue, nervous tissue.
 - Examples in plants: epidermis, cambium.
 - Many tissues have extracellular material between the cells.
- Epidermis: a layer of cells on the underside and the upper side of a leaf.
 - The epidermal tissue protects the plant from external influences.
 - Between the epidermis cells there are stomata: small openings, mainly on the underside of the leaf.
 - Plants take in carbon dioxide and release oxygen through the stomata.
- Cambium: a layer of cells just under the bark.
 - The cambium forms new wood on the inside (the side near the middle of the trunk).
 - Annual ring: all the wood that is formed in a single year.
 - An annual ring consists of a thicker layer of light wood (from the spring) and a thinner layer of dark wood (from the summer).
 - The oldest wood is in the middle of the trunk.
 - The number of annual rings at the base of the trunk tells you how old the tree was.

BASICS 4

CELLS**7 You can name parts of animal cells with their features and functions.**

- Cytoplasm (cell plasma): a thick fluid consisting of water with dissolved substances.
- Cell membrane: a thin skin around the cytoplasm.
 - Proteins in the cell membrane regulate the uptake and secretion of substances.
- Nucleus: controls everything that happens in the cell.
 - The nucleus is surrounded by the nuclear membrane.

8 You can name parts of plant cells with their features and functions.

- Plant cells have the parts that animal cells have: cytoplasm, cell membrane and nucleus.
- Plant cells also have parts that animal cells don't have: vacuole, plastids, cell wall.
- Vacuole: a 'sac' filled with sap.
 - Most plant cells contain one large vacuole.
- Plastids: chloroplasts, chromoplasts and amyloplasts.
 - Photosynthesis takes place in chloroplasts.
 - Chromoplasts give flowers and fruits their colour.
 - Amyloplasts store starch.
 - Plastids can change from one type to another.
- Cell wall: a strong layer surrounding the cell.
 - Cell walls are not part of the cell; they are extracellular material.
- Cell organelles: the parts of a cell that have their own function.

BASICS 5

THE NUCLEUS

9 You can name the features of chromosomes.

- Organisms have a fixed number of chromosomes in their body cells.
 - Body cells: the cells that make up your body.
 - The nucleus of a human body cell contains 46 chromosomes.
- The chromosomes control everything that happens in the cell.
 - Chromosomes: thin ‘threads’ in every nucleus.
 - Chromosomes are only visible when a cell divides.
 - Chromosomes consist largely of DNA.

10 You can describe the structure and function of DNA.

- DNA consists of two strands to which bases are attached.
 - The four bases are A, C, G and T.
 - The four bases form pairs: A pairs up with T and C with G.
- DNA contains the information for your hereditary characteristics.
 - The information is stored as the order in which the base pairs appear.
 - You inherit the information in the DNA from your parents.
 - Your environment and your lifestyle also influence your characteristics.
- A gene consists of the base pairs that are needed for one or more characteristics.
 - Each body cell contains all the genetic information of an organism.
 - A cell only uses the genes that it needs.

BASICS 6

CELL DIVISION

11 You can describe how a cell divides.

- Cell division leads to new cells.
 - If more new cells are created than old cells die, you grow.
- The cell cycle:
 - Before a cell divides, a copy is created of each chromosome.
 - The chromosomes become visible.
 - Two nuclei are created, each with a full set of chromosomes.
 - The cell divides. The cell that is dividing is called the parent cell. The cells that are created are called the daughter cells.
 - Plasma growth: the daughter cells grow because new cytoplasm is created.
 - After cell division, the daughter cells contain the same information as the parent cell.
- One of the daughter cells develops into a specialised cell.
 - The other daughter cell can divide again.

12 You can name the features of stem cells.

- Stem cells can divide an infinite number of times.
 - Stem cells are responsible for growth and for the recovery of tissues.
- One or more types of specialised cells can be created from stem cells.
 - All the different types of cells can be produced from embryonic stem cells.

EXTRA 7

SINGLE-CELLED ORGANISMS (IN DEPTH)

13 You can explain how an organism can consist of a single cell.

- Single-celled organisms consist of just one cell.
 - A single-celled organism shows all the life processes.
- Amoeba:
 - Moves by forming pseudopods. The cytoplasm uses the pseudopods to move in a particular direction.
 - Feeds by creating food vacuoles. Pseudopods enclose food (e.g. bacteria). The food is digested in food vacuoles and then absorbed into the cytoplasm.
 - Undigested residues are eliminated through the cell membrane.
- Paramecium:
 - Moves using cilia.
 - Feeding: the cilia make the food move via the mouth pore into a food vacuole. The food is digested in food vacuoles and then absorbed into the cytoplasm.
 - Undigested residues are eliminated through the anal pore.

EXTRA 8

DNA TESTING (EXTENSION)

14 You can explain that DNA tests can be used to show people are related.

- Every human being has unique DNA (except in the case of identical twins).
 - Someone can be identified using their DNA.
 - The DNA of relatives shows more similarities than the DNA of people who are not related.
- DNA kinship analysis: tests whether people are related by comparing their DNA.
 - The police can use DNA testing to solve crimes.
- DNA profile: a drawing or table of someone's DNA.
 - A DNA profile is created in four steps: isolating, cutting into pieces, replicating and measuring.
 - A chromosome pair consists of two chromosomes: one from the father and one from the mother. The information in the DNA can differ between chromosomes.
 - Repeating pieces of DNA: repetitions of the same base sequence in the DNA. The number of repetitions can differ between the two chromosomes of a pair.
 - Bands: strips indicating the number of repetitions.
 - In a child, one band comes from the mother and one band from the father.

RESEARCH

LEARNING HOW TO DO RESEARCH & PRACTICAL ACTIVITIES

15 You can name the parts of a microscope and their features and functions.**16 You can work with a microscope.****17 You can prepare a specimen.**

 Go to the *Flash cards* and the *Diagnostic test*.

3 Classification

Biologists discover thousands of new organisms every year. Estimates of the total number of species on Earth range from ten million to a hundred million. Those species are then classified into smaller and smaller groups.

BASICS

1	Smaller and smaller groups	166
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EXTRA

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TO FINISH

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1 Smaller and smaller groups

LEARNING OBJECTIVES

- 3.1.1 You can classify organisms into domains and kingdoms.
- 3.1.2 You can list the features of animal, plant, fungal and bacterial cells.
- 3.1.3 You can list the groups that are used for further classification within a kingdom.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	3.1.1	3.1.2	3.1.3
Remembering	2abc	3	4a
Understanding	1, 2d, 5	5	4bcde, 5
Using	10ae	6, 8, 10abce	7, 10d
Analysing	9	9	

About 1.8 million species of organisms have been discovered and described so far. And there are lots of other species that haven’t been discovered yet. To let us get a good overview, organisms are classified.

MAKING GROUPS

When you go to school, you take a collection of writing implements with you. You could classify these writing implements as ball-points, pencils, felt pens, and so forth. You could also classify them by colour: all the red ones together, all the blue ones, and so forth. The colour is a characteristic of the writing implement.

When organisms are being classified, you split a collection of organisms into groups with the same characteristics or features. A **feature** is a property you can use to distinguish one organism from other organisms.

DOMAINS AND KINGDOMS

Biologists use the features of cells for classifying organisms. They also look at characteristics of the DNA. DNA studies in particular have taught biologists lots of new things about organisms. That means they know more about the best ways to classify organisms.

Various categories are possible when classifying organisms. This topic teaches you a classification that was produced in 2015 by a group of biologists led by Michael Ruggiero.

All life on Earth is first divided into two main groups or ‘domains’: **prokaryotes** and **eukaryotes** (see figure 1). Each domain can be categorised further into smaller groups: the **kingdoms**. The prokaryotes are subdivided into two kingdoms: bacteria and archaea (pronounced ‘ark-ear’ or ‘ark-ayer’). The eukaryotes are subdivided into five kingdoms: chromista, protozoa, fungi, plants and animals. Biologists classify humans in the animal kingdom.

fig. 1 Classification of life on Earth into two domains and seven kingdoms.

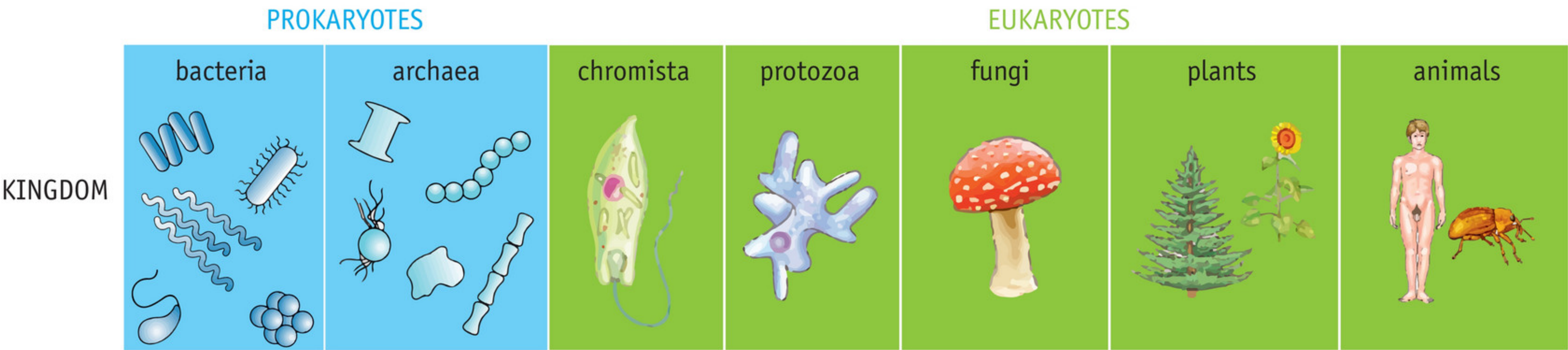
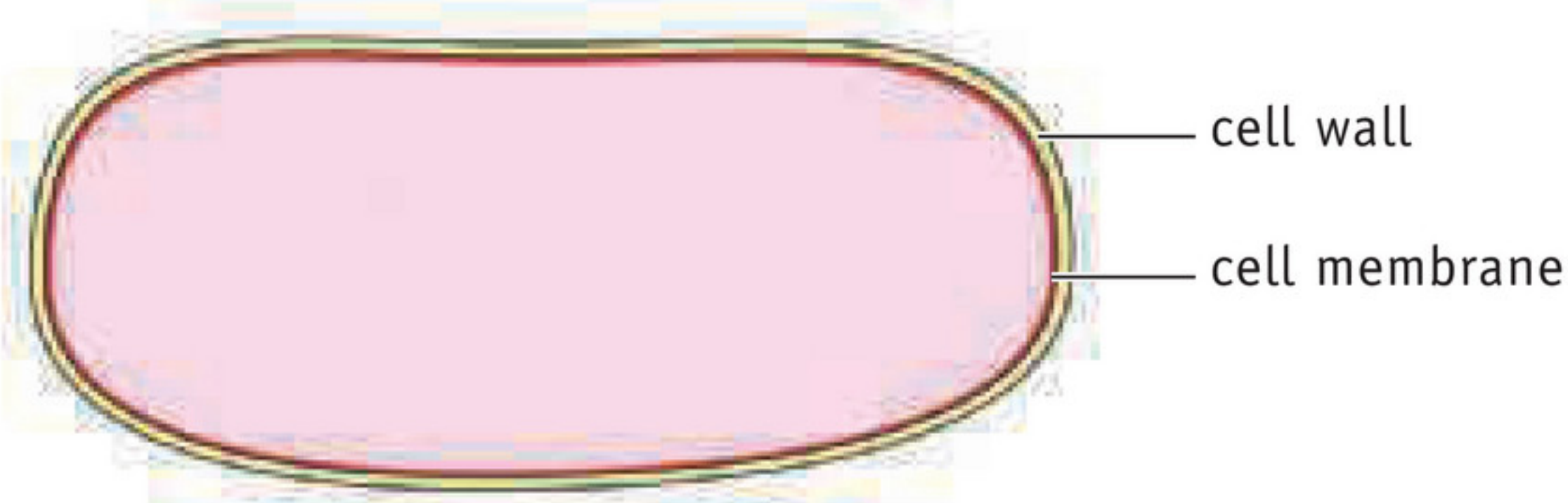
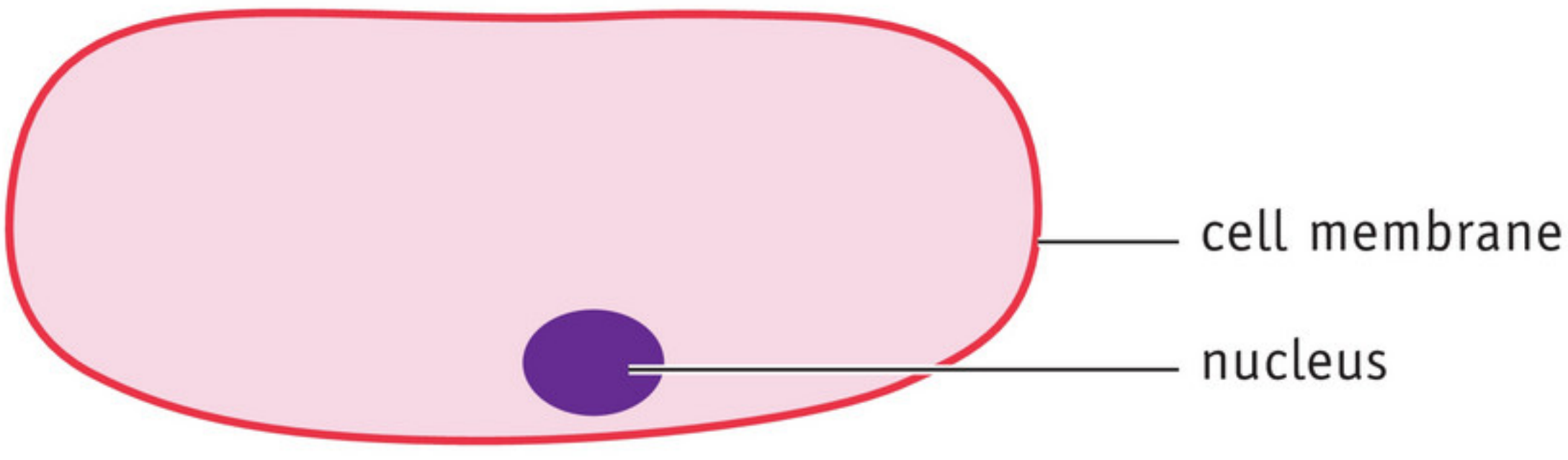
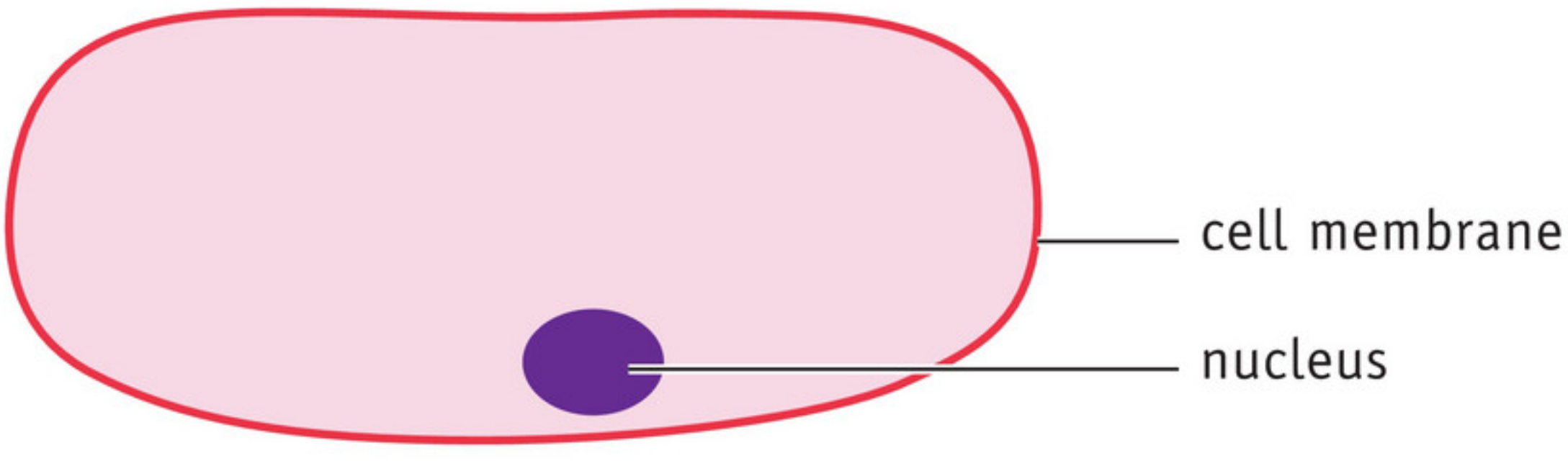
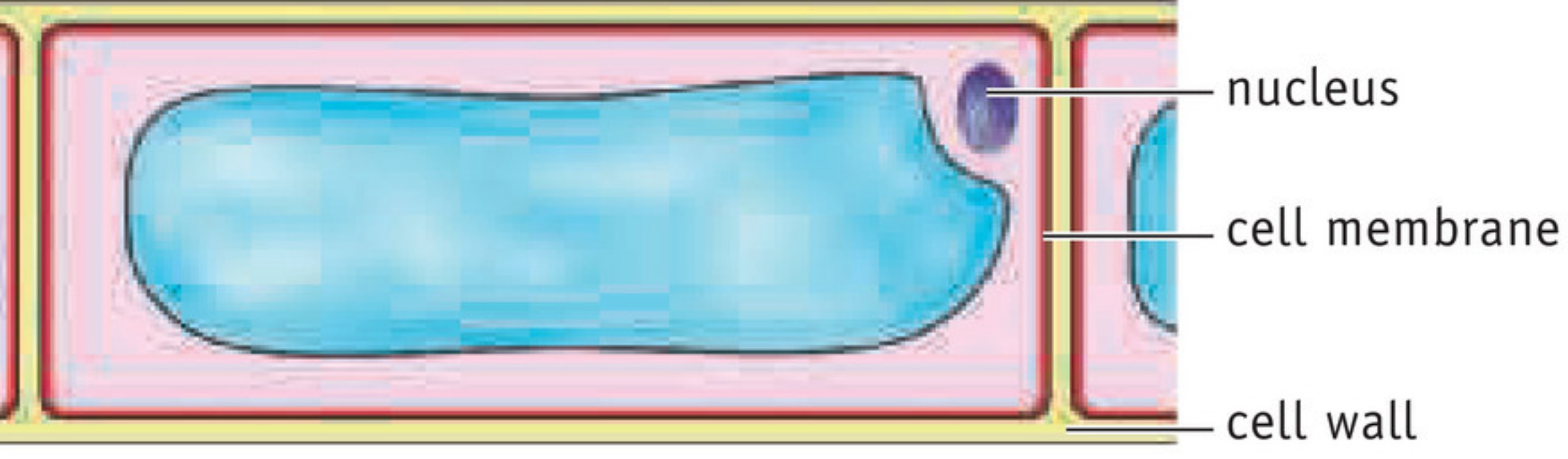
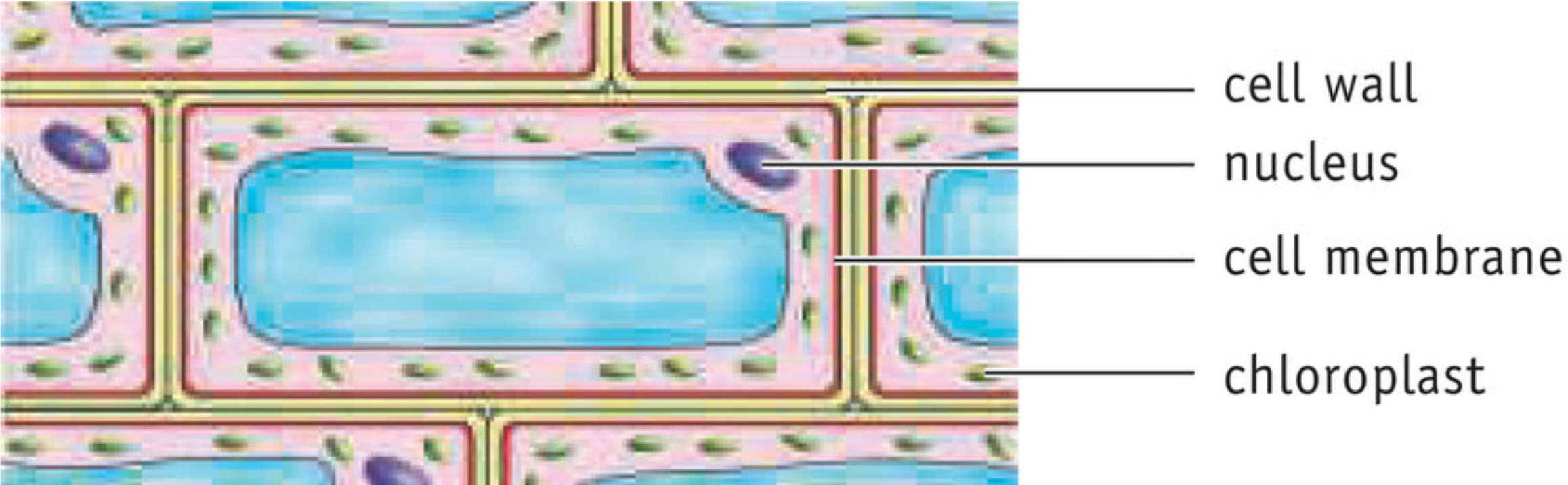
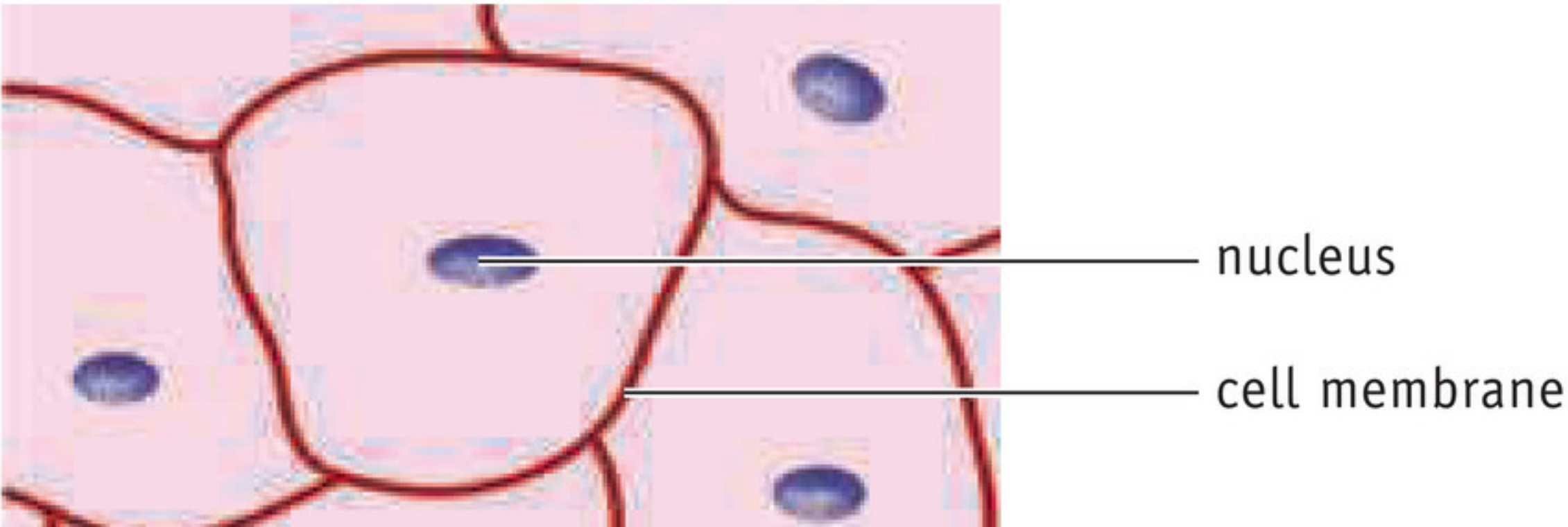


fig. 2 Characteristics of the seven kingdoms.

DOMAIN	KINGDOM	CELL FEATURES	ORGANISM
PROKARYOTES	Bacteria		unicellular
	Archaea		unicellular
EUKARYOTES	Chromista	 • sometimes have a cell wall • sometimes have chloroplasts	unicellular or multicellular
	Protozoa		unicellular
	Fungi		unicellular or multicellular
	Plants		unicellular or multicellular
	Animals		multicellular

CELL CHARACTERISTICS

Bacteria and archaea are **unicellular**: they consist of a just one small cell. Most eukaryotes are single-celled (unicellular) too. Organisms can also be **multicellular**. A human is made up of many billions of cells, for example. A lot of animals, plants and fungi (moulds) are multicellular.

When classifying organisms, the first thing biologists look at are the features of the cells. Those are the nucleus, the cell wall and chloroplasts (see figure 2):

- *Nucleus*. Eukaryotic cells have a nucleus. Prokaryotic cells do not. Bacteria and archaea are organisms whose cells do not have nuclei.
- *Cell wall*. Animals do not have cell walls around their cells. The cells of bacteria, archaea, fungi and plants do have cell walls.
- *Chloroplasts*. The cells of plants have chloroplasts in the cytoplasm. Bacteria, archaea, fungi (moulds) and animals do not have chloroplasts.

SMALLER AND SMALLER GROUPS

Further categorisation of the kingdoms gives smaller and smaller groups (see figure 3).

fig. 3 Classifying organisms into smaller and smaller groups.

KINGDOMS

are subdivided into

PHYLA

are subdivided into

CLASSES

are subdivided into

ORDERS

are subdivided into

FAMILIES

are subdivided into

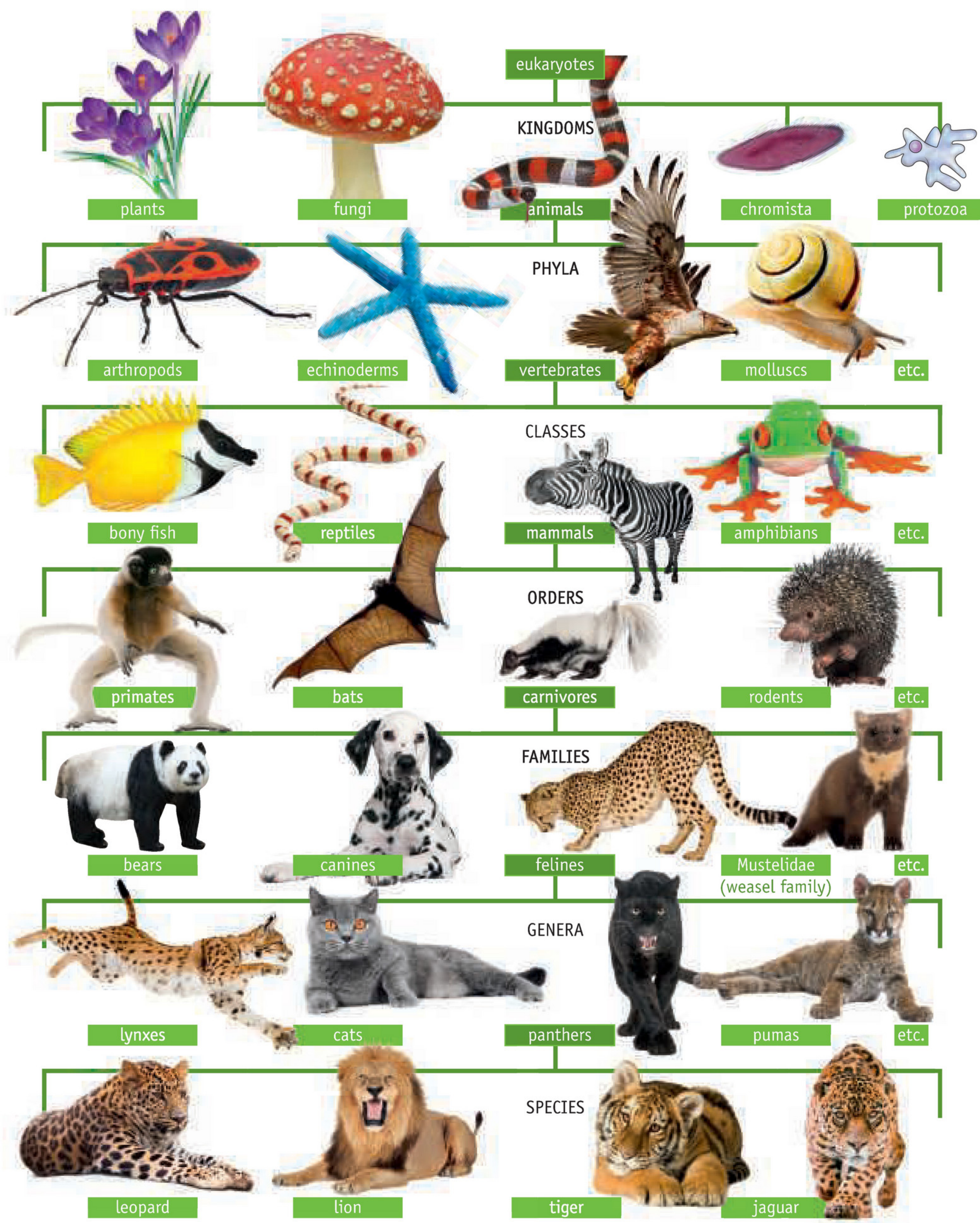
GENERA

are subdivided into

SPECIES

As an example, figure 4 shows further subdivisions of the animal kingdom. You can see four phyla (the plural of phylum) of animals, though there are more. The vertebrate phylum is subdivided further into four classes (as an example) and so it continues. Each time, one group is taken as an example and then subdivided further.

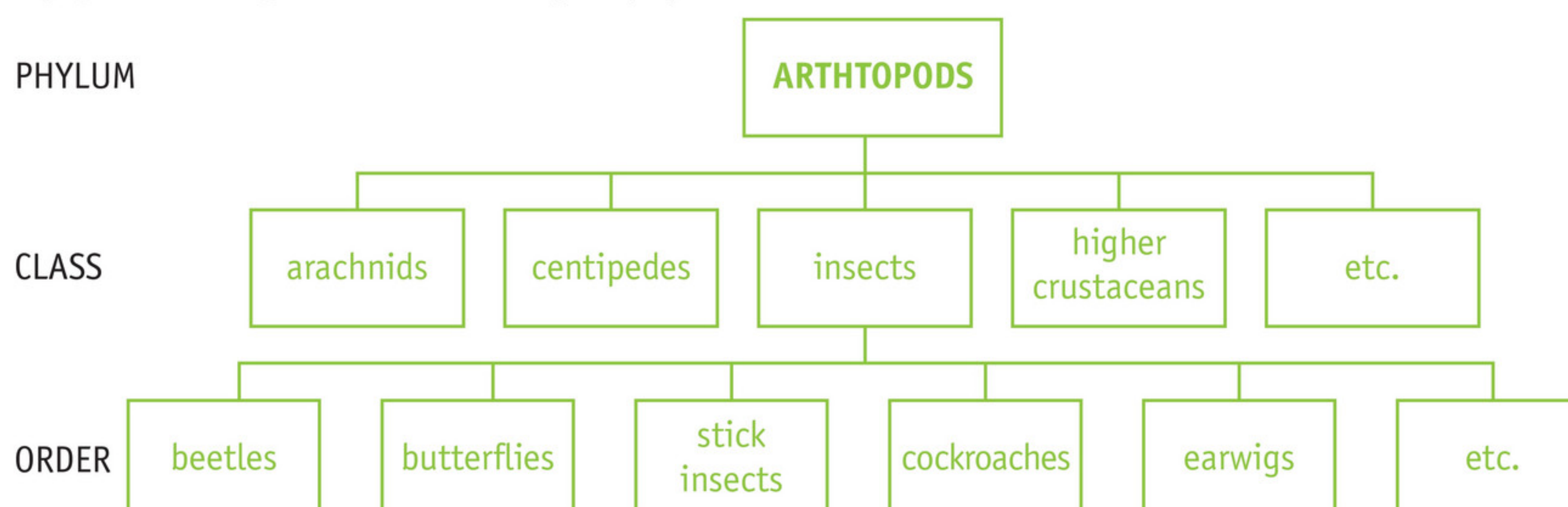
fig. 4 Further classification of the animal kingdom.



BRANCHING TREE

The way we classify organisms into smaller and smaller groups can be represented as a **branching tree**. Figure 4 is a branching tree with photos. Figure 5 shows a branching tree in schematic form for the arthropod phylum. Some of the orders of the class ‘insects’ are also shown.

fig. 5 Branching tree of the arthropod phylum.



KNOWLEDGE

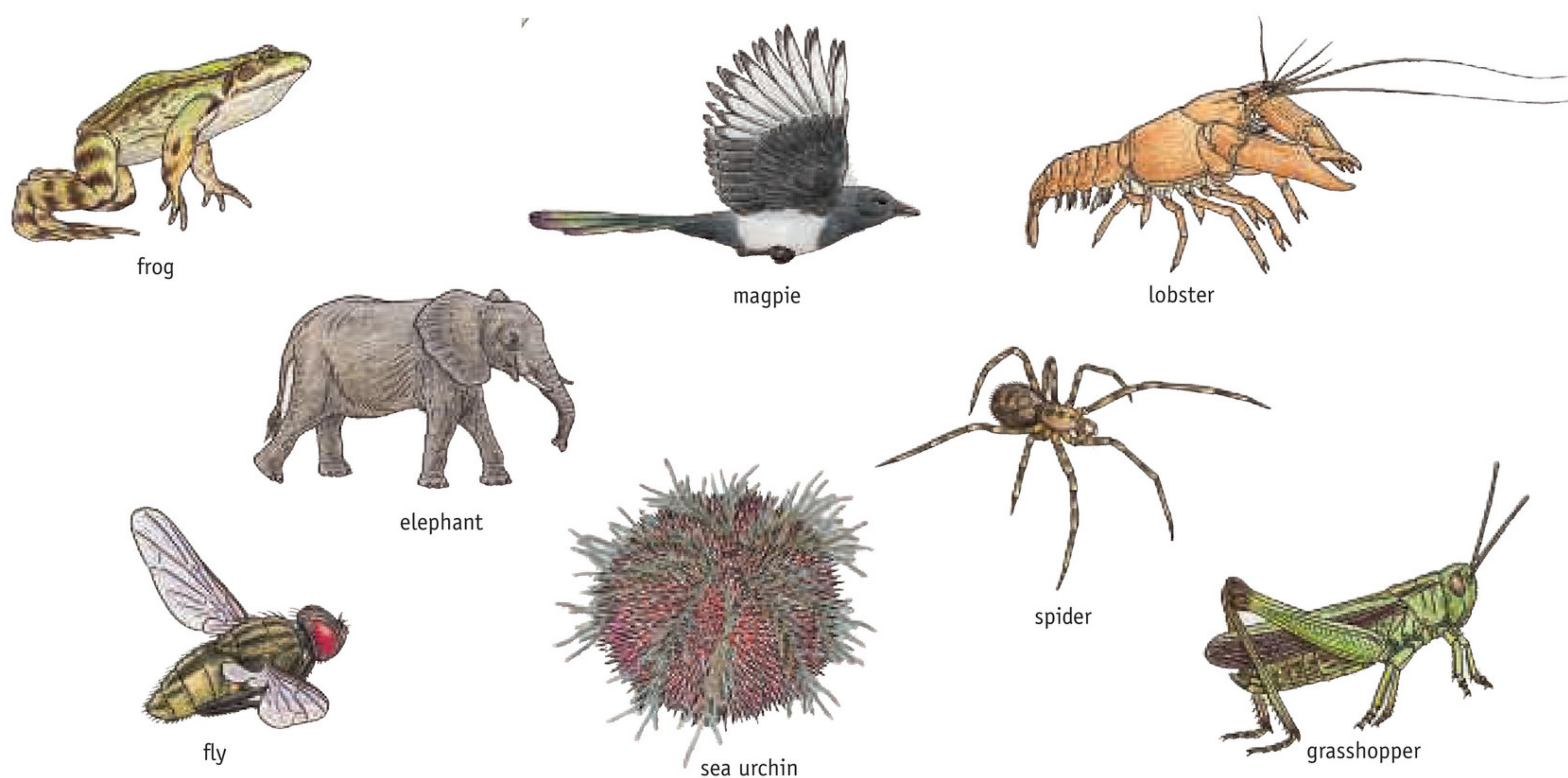
1

The collection of animals shown in figure 6 can be classified in various ways.

You will be doing this exercise with the pupil next to you.

- One pupil thinks of one of the animals in figure 6.
- The other tries to work out which animal it is by asking two questions.
 - You are only allowed to ask about features of the animal. So you aren't allowed to ask “Is it the elephant?” straight away
 - The questions can only be answered yes or no.
 - After you have asked two questions, you have to say the correct animal. You'll only be able to do that if you have asked about the correct features. To do this, you must first have classified the group of animals in your own thoughts.
- Change over after the animal has been guessed.

fig. 6 A collection of animals.



2

- a** What two domains are organisms classified into?
b In which domain do all the organisms consist of a single cell?
c What five kingdoms are eukaryotes classified into?

- 1
 2
 3
 4
 5

- d** In which three kingdoms do all the organisms consist of a single cell?

3

Which features do the cells have in the kingdoms?

- | | | |
|---|----------|---|
| 1 | bacteria | <i>nucleus / cell wall / chloroplasts / all these cell features</i> |
| 2 | archaea | <i>nucleus / cell wall / chloroplasts / all these cell features</i> |
| 3 | fungi | <i>nucleus / cell wall / chloroplasts / all these cell features</i> |
| 4 | plants | <i>nucleus / cell wall / chloroplasts / all these cell features</i> |
| 5 | animals | <i>nucleus / cell wall / chloroplasts / all these cell features</i> |

4

Further categorisation of a kingdom gives smaller and smaller groups.

- a** Put these groups in the correct sequence. Number 1 has been given.

- family
 genus
 class
 order
 1 kingdom
 species
 phylum

- b** Are there more families than there are orders, or are there fewer? Explain your answer.

- c** Vertebrates are classified into *families / classes / orders / phyla*.

- d** Use figure 4.

What phylum does a lynx belong to?

- ☐ A arthropods
☐ B vertebrates
☐ C echinoderms
☐ D molluscs

- e** Use figure 4.

Which groups does a lion belong in? Start with the domain and work down to the species.

5



Summary

Make a summary of this Basics section. Put the classification after ‘kingdom’ into smaller and smaller groups and complete the table.

kingdom → → →
→ → →

Domain	Prokaryotes		Eukaryotes				
Kingdom							
Organism							
Nucleus							
Cell membrane							
Cell wall							
Chloroplasts							

INSIGHT

6

Figure 7 shows you a collared anteater with its young. Which features do the cells of a collared anteater have? Explain your answer using the classification into domains and kingdoms.

fig. 7 Collared anteater.

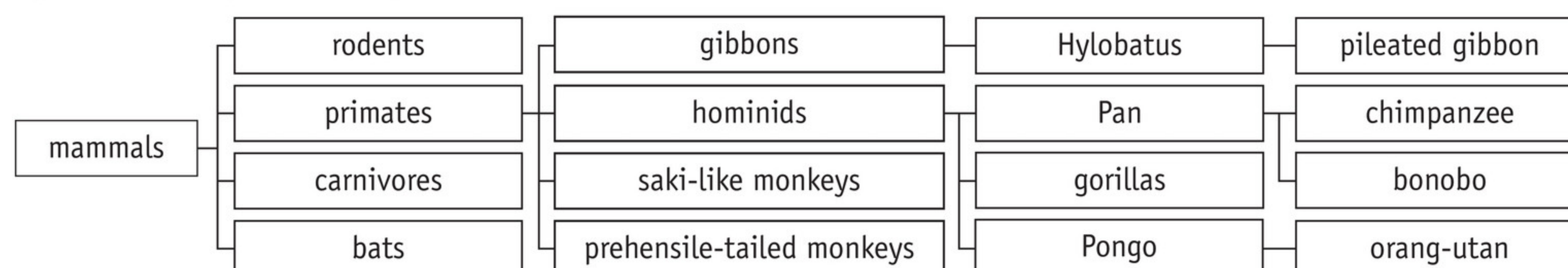


7

Figure 8 shows a branching tree of the primates (monkeys and prosimians).

- a** What would you call the group 'gibbons'?
- ☐ A a family
 - ☐ B a genus
 - ☐ C a class
 - ☐ D an order
- b** The bonobo and the orang-utan belong to the same *class / order / family / genus / species*.

fig. 8 Branching tree of the primates.



8

Carnivorous plants trap and digest flies and other insects, or just occasionally even mice. There is also one carnivorous plant in the Netherlands: the sundew (see figure 9).

- a** Do all the cells of a sundew have cell walls? Explain your answer.
- b** Do all the cells of a sundew have chloroplasts? Explain your answer.
- c** The leaf insect in figure 10 looks like a leaf but it is actually an insect. Does a leaf insect have chloroplasts in its cells? Explain your answer.

fig. 9 A sundew.

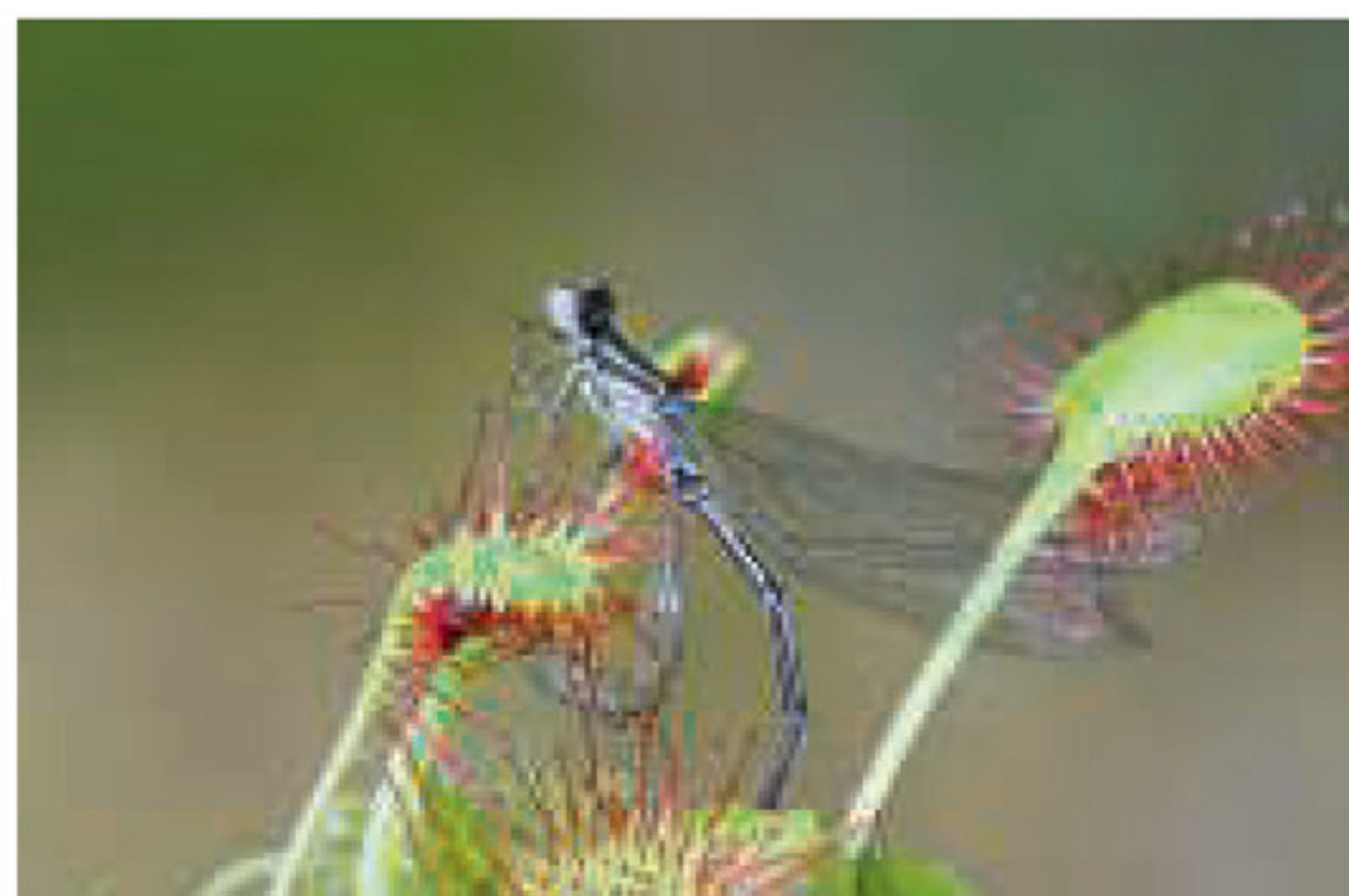


fig. 10 A leaf insect.

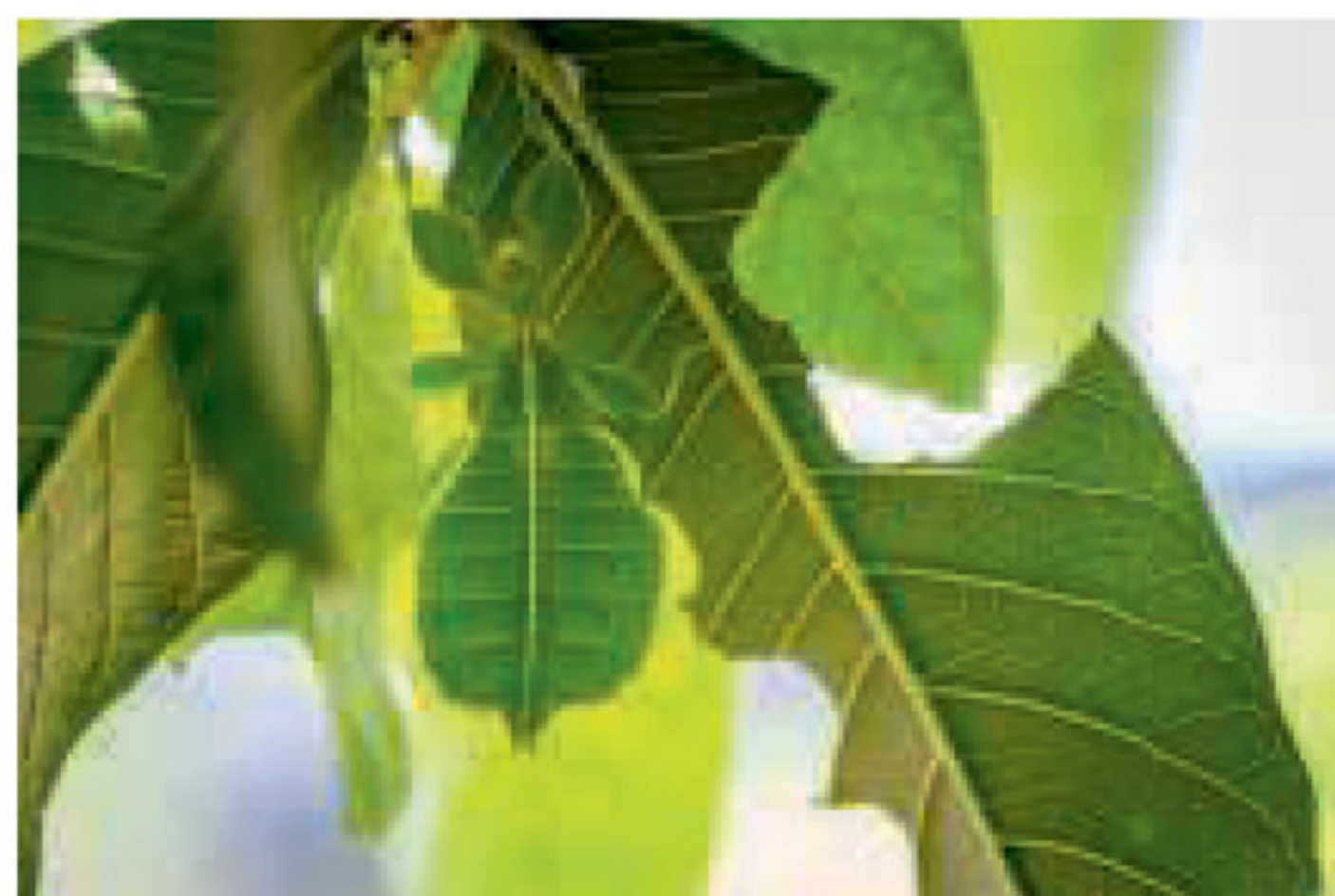
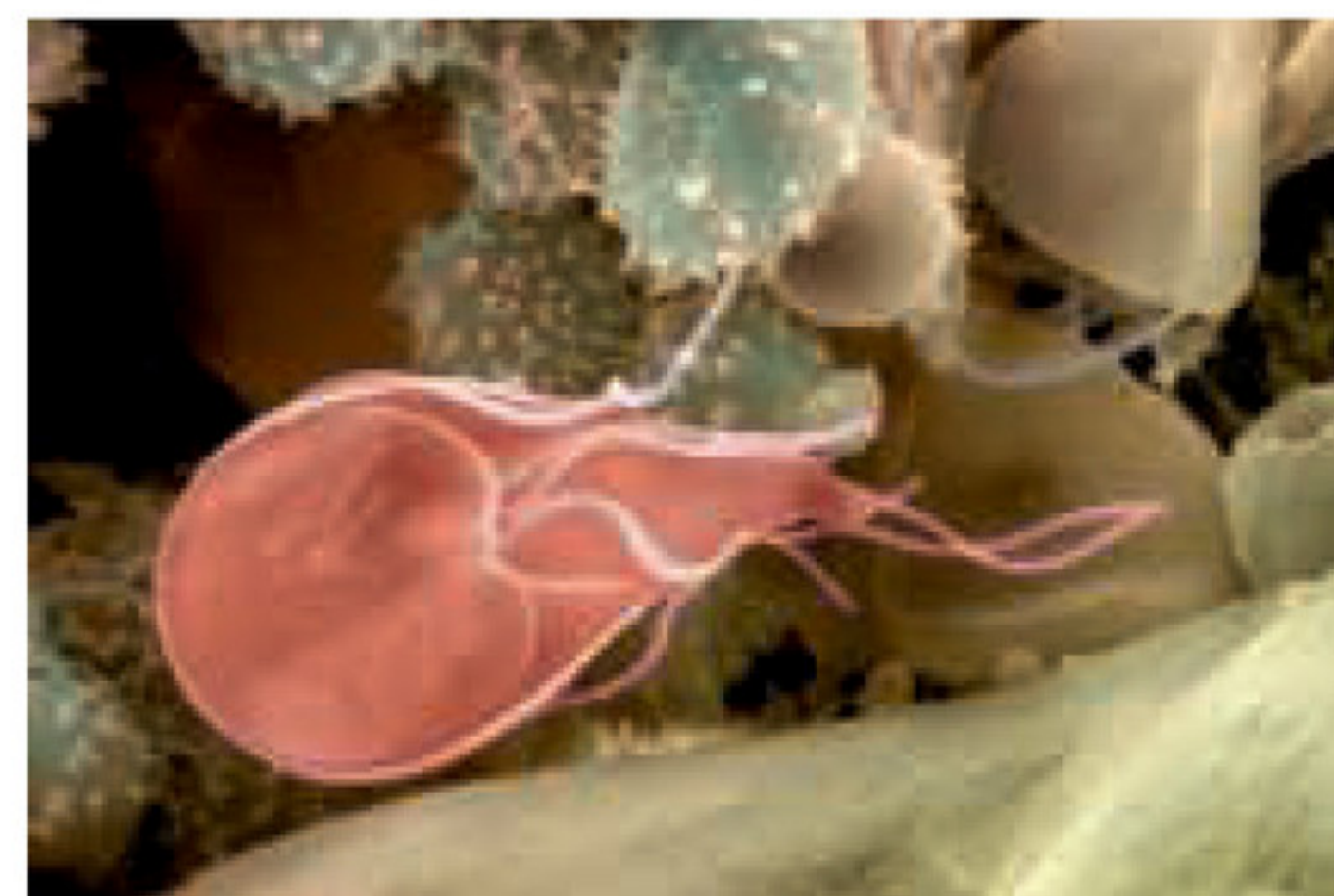


fig. 11 A single-celled protozoon with cilia.



+ 9

Paramecia and entamoebae are single-celled organisms. They used to be classified as animals, but a paramecium is now classified in the kingdom of the chromista and an entamoeba is in the kingdom of the protozoa (which means 'primeval animals').

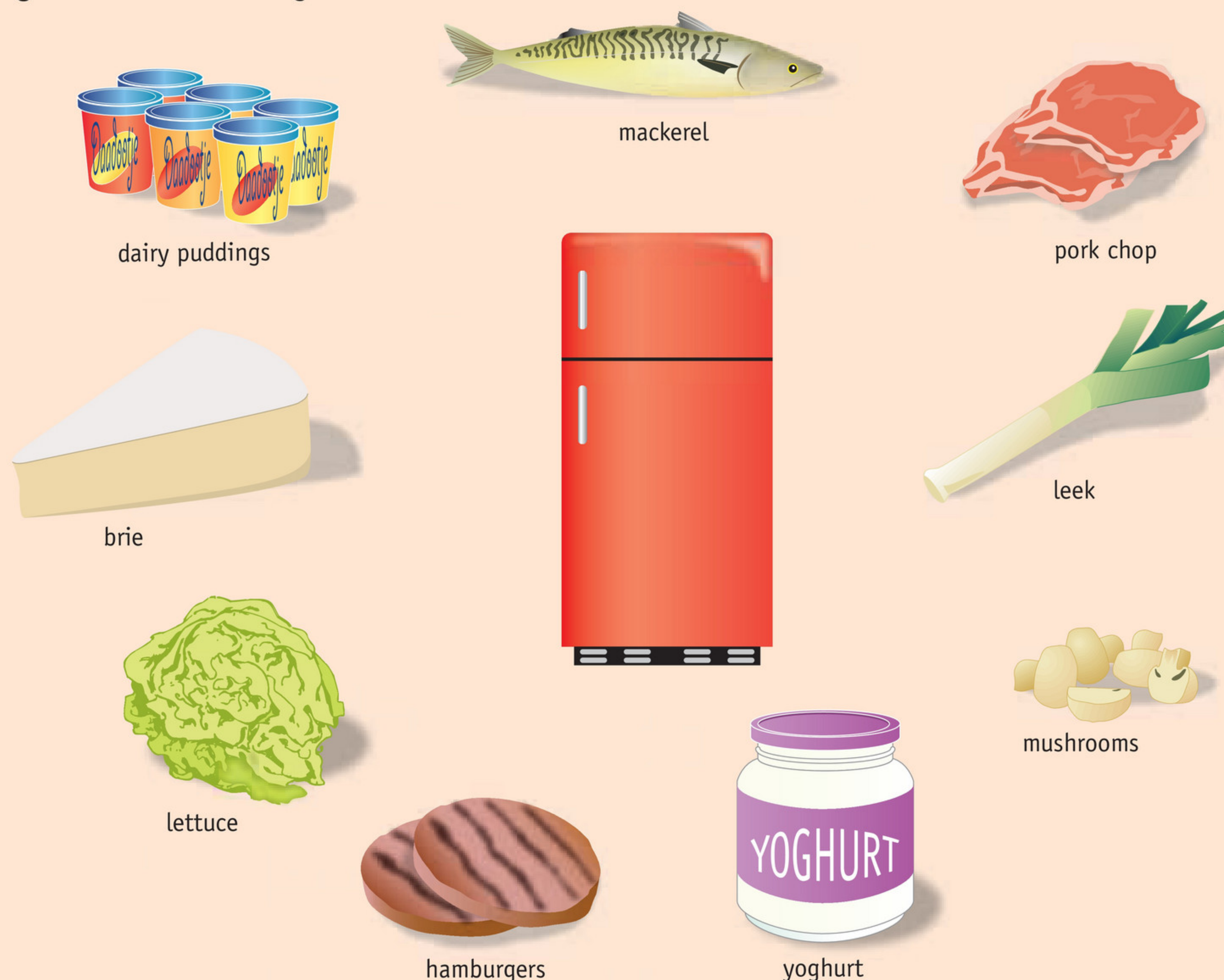
- a** Which cell features led to these unicellular organisms being classed as animals in the past?
- b** Some unicellular organisms have cilia (vibrating hairs like a tail - see figure 11). Which of the life processes does this mean they have in common with animals?

HOW IT FITS TOGETHER the living world

ORDER IN THE FRIDGE

Our refrigerators are full of all kinds of organisms or the remains of organisms. You will find not only edible plants and animals but also edible fungi and bacteria. Brie, for instance, is a cheese that is coated with a white layer of a mould. Lots of people think these moulds taste really nice, in the same way that people like the popular fungi known as mushrooms. There are also tasty bacteria. Yoghurt is made from milk that lactic acid bacteria have been added to. They make the milk thicker and give it a fresh, sharp taste. That means that natural yoghurt and yoghurt puddings are full of good bacteria.

fig. 12 Foods from the fridge.



10

Read the text called 'Order in the fridge'.

Figure 12 shows you a fridge containing various foods. These foods are all made of organisms or parts of organisms.

The animal cells in milk are broken down in the factory by heating them. You do not have to take account of those cells. You can also ignore the bacteria that are present on all foods.

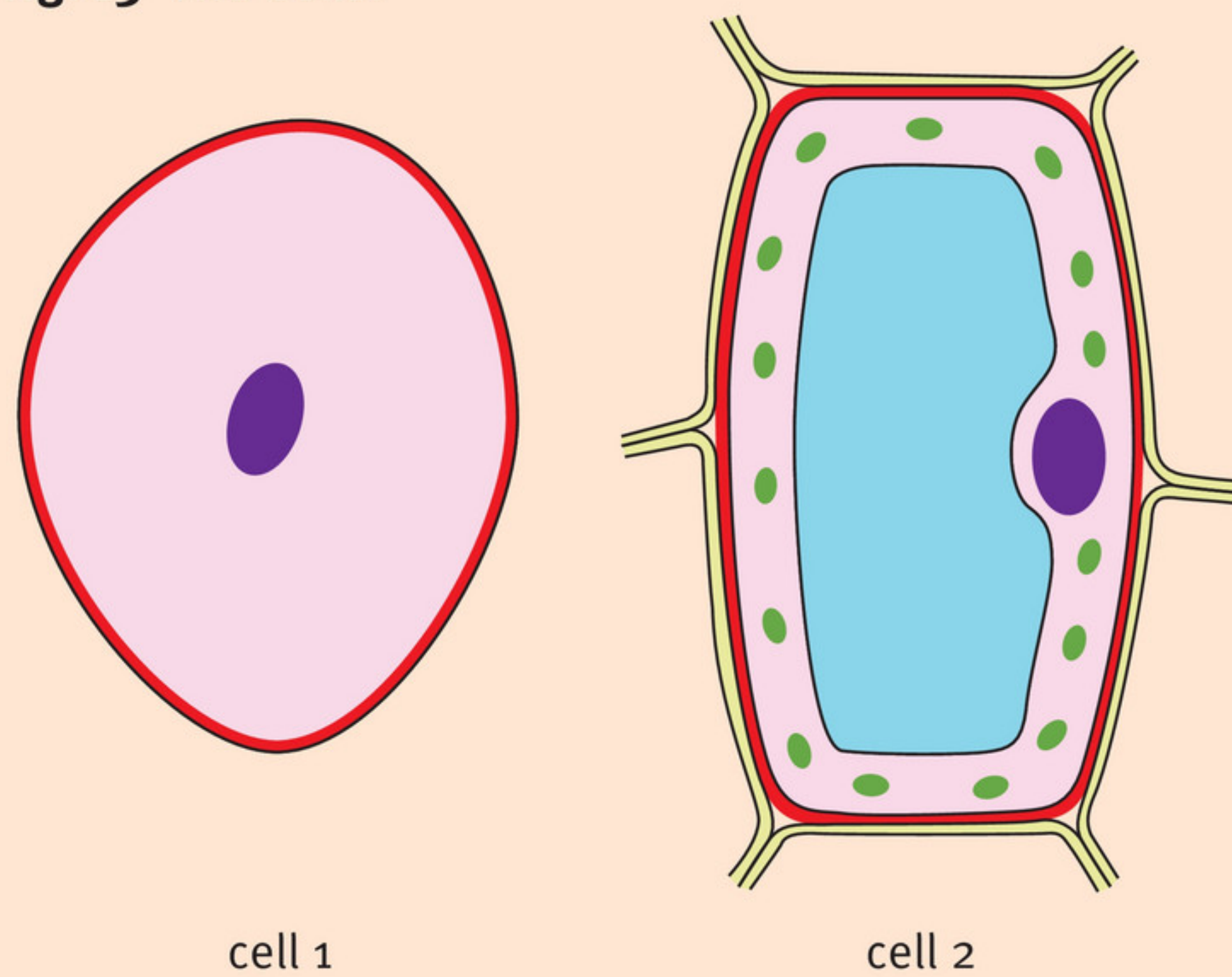
- Which foods contain only prokaryotic cells?
brie / mushrooms / hamburgers / pork chop / dairy puddings / mackerel / leek / lettuce / yoghurt
- Figure 13 gives schematic drawings of two cells.
Which foods contain cells like cell 1?
brie / mushrooms / hamburgers / pork chop / dairy puddings / mackerel / leek / lettuce / yoghurt
- Which foods contain cells like cell 2?
brie / mushrooms / hamburgers / pork chop / dairy puddings / mackerel / leek / lettuce / yoghurt

d Which phylum and class do the meat products in the refrigerator come from?

e Classify the foods according to the cell features into four kingdoms:

- 1 bacteria:
- 2 fungi:
- 3 plants:
- 4 animals:

fig. 13 Two cells.



 Go to the *Flash cards* and the *Test yourself* section.

2 Similarity and kinship

LEARNING OBJECTIVES

- 3.2.4 You can distinguish between species and breeds.
- 3.2.5 You can explain how the classification of organisms depends on similarity and kinship.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	3.2.4	3.2.5	3.1.3*
Remembering			
Understanding	1, 2, 4	3, 4	
Using	5abc, 10d	6a, 8a, 9, 10ac	6
Analysing		5d, 7, 8b, 10be	7a

* You can find this learning objective in another unit.

A species is the smallest group of organisms that remains after classification. Even so, organisms of the same species can still differ from one another – take dogs, for example.

SIMILARITY

Organisms from the same genus have a lot of similarities. Organisms that only belong to the same kingdom show far fewer similarities. A lion and a tiger, for instance, belong to the same genus (panthers) and are very similar. A starfish and a bird of prey only belong to the same kingdom (animals) and do not look much like each other at all. The more similarities there are between two organisms, the more they will be classified into the same groups.

SPECIES

An African elephant and an Asiatic elephant look very similar (see figure 1). They both belong to the order Proboscidea (animals with trunks) and the family Elephantidae (elephants). Even so, they are not the same species. Organisms only belong to the same species if they can reproduce together and the offspring are also fertile. In other words, their descendants must also be able to reproduce. An African elephant and an Asiatic elephant cannot have fertile offspring together. So organisms that look a great deal like one another do not have to belong to the same species.

fig. 1 Two different species of elephant.



1 African elephant



2 Asiatic (Indian) elephant

BREED

A miniature Dachshund and a Great Dane look a lot less like each other than the two elephant species do. Nonetheless, these dogs belong to the same species. They can reproduce together and have fertile offspring. A miniature Dachshund and a Great Dane are two different **breeds** of the dog species (see figure 2). A species can be made up of several breeds (or races). All breeds of dog belong to the dog species.

fig. 2 Two breeds within the same species.

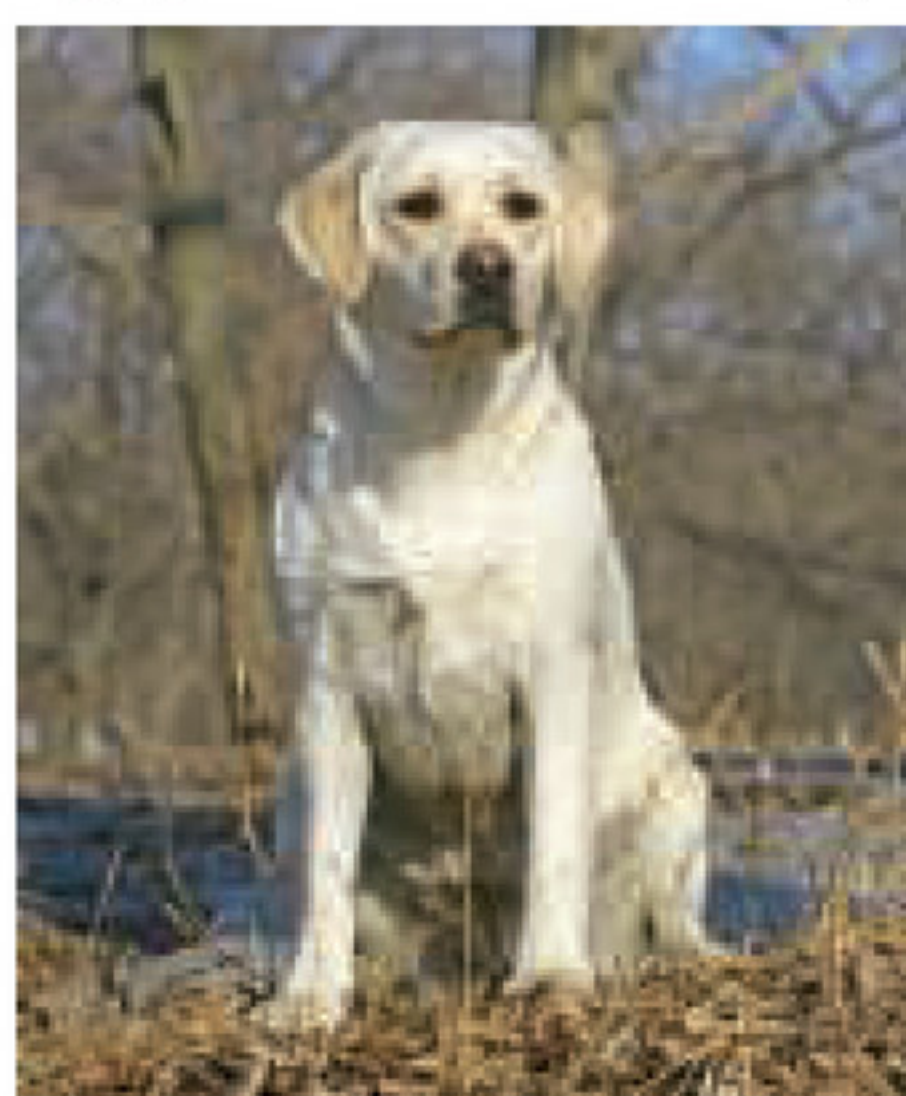


1 miniature
Dachshund

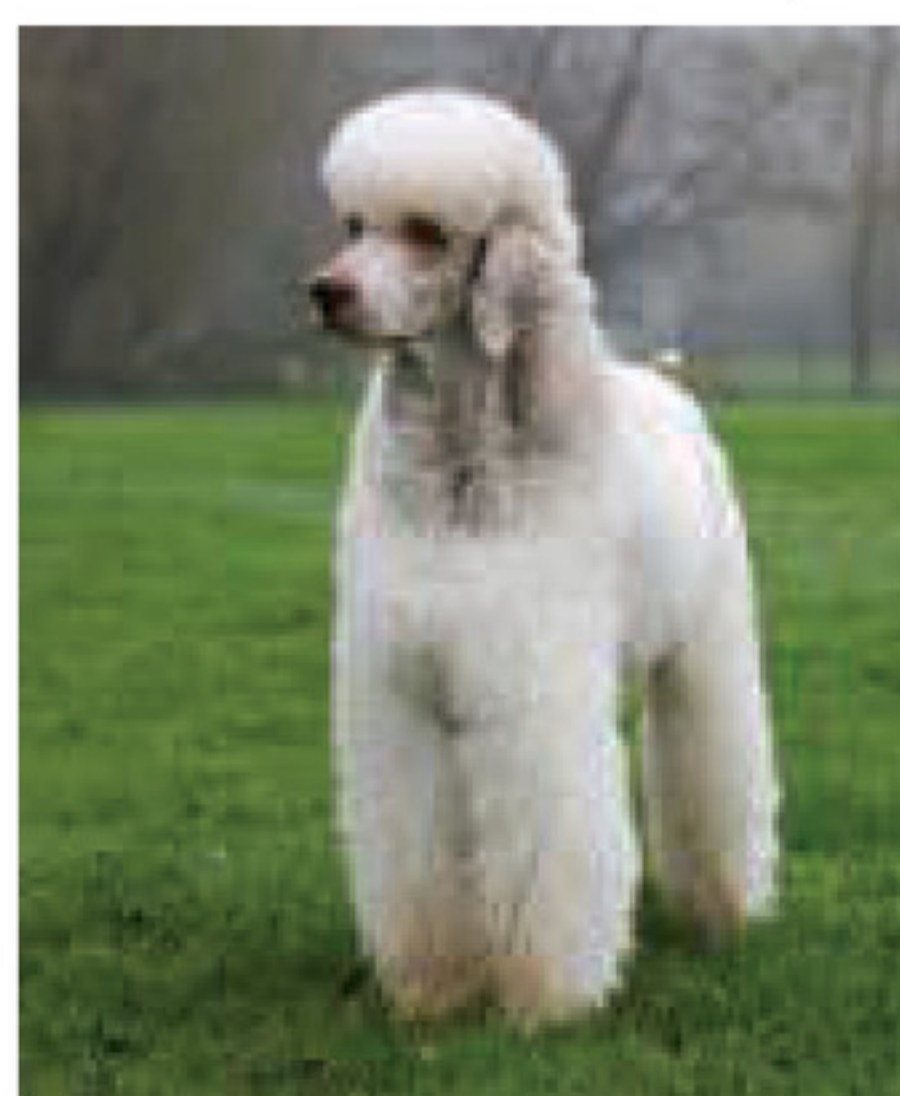
2 Great Dane

A miniature Dachshund and a Great Dane are not so likely to mate, but it happens a lot with other dog breeds and they have fertile offspring (see figure 3).

fig. 3 A Labrador and a poodle can have fertile offspring.



1 Labrador



2 poodle



3 fertile offspring
(Labradoodle)

EVOLUTION

Organisms that belong to the same species have lots of similarities. Figure 4 shows you some snails that all belong to the same species. The snails look very much alike, but there are small differences among them. There are for example both lighter and darker snails. This is called **variation**.

In an area where the ground is dark-coloured, a dark snail will be less easy to see. Birds can spot the paler snails more easily and will eat more of them. More of the dark snails survive and they have offspring that will also be dark more often. This is called **selection**. As a result of selection, the light-coloured snails will slowly become less common than the darker ones.

fig. 4 Evolution through variation and selection.



1 variation



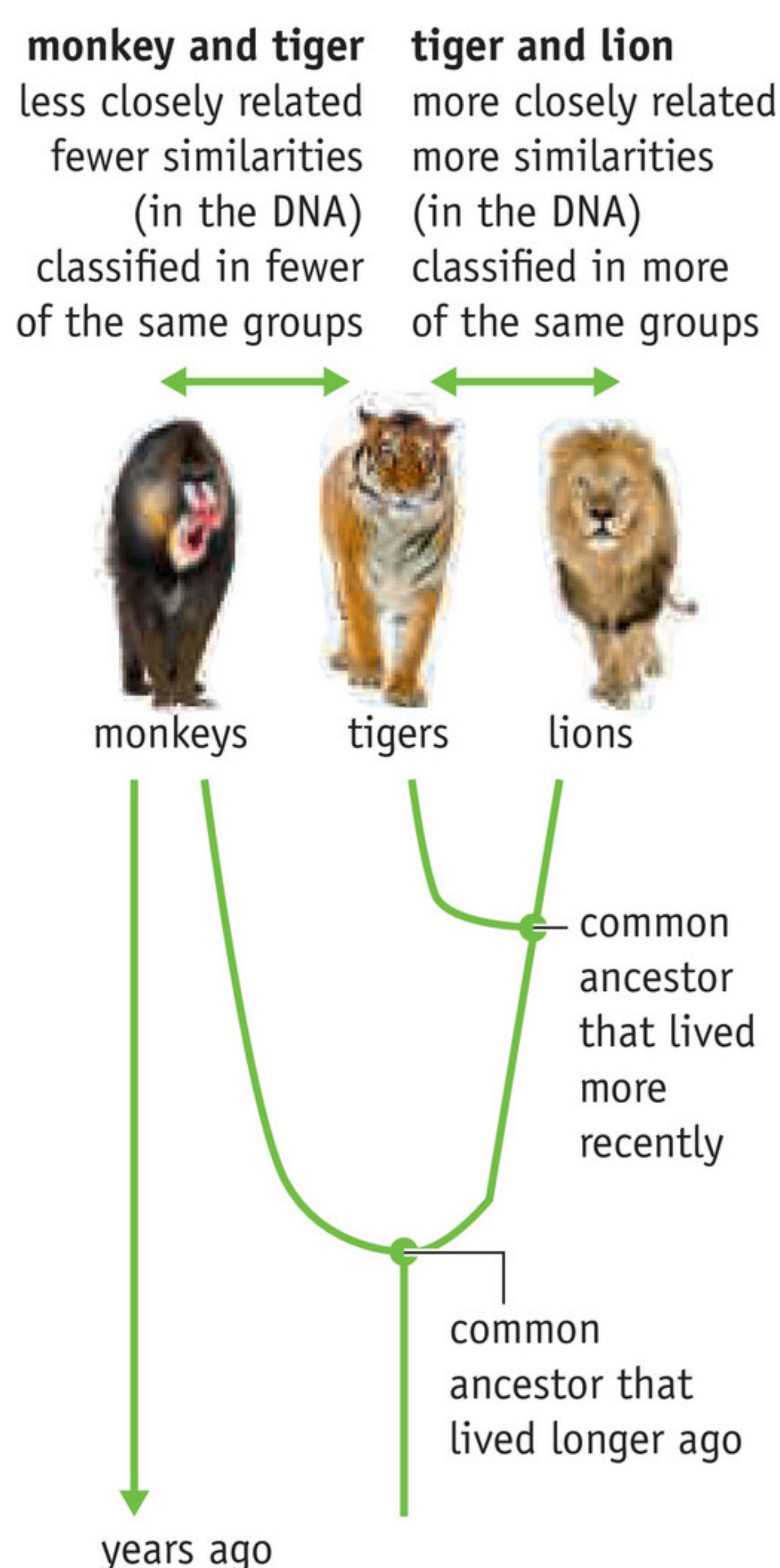
2 selection

Variation and selection together allow species to evolve gradually. A species may even disappear completely. New species can also appear. The development of life on Earth in which species arise, change and/or disappear is called **evolution**. This can also result in different species arising from a common ancestor.

KINSHIP

Figure 5 shows you that a tiger and a lion have a common ancestor. So do a tiger and a monkey, though that was much longer ago. The tiger and the lion are therefore more closely **related** than the tiger and the monkey. The longer ago two species arose from a common ancestor, the less close the relationship is. The more closely related the species are (the greater the kinship), the more similarities there are in their DNA.

fig. 5 Ancestry of monkeys, tigers and lions.



KNOWLEDGE

1

Figure 3 shows you a Labrador, a poodle and a Labradoodle.

- Do these animals belong to the same species? Explain your answer.
- A song canary and a crested canary can have fertile offspring.
Are the song canary and the crested canary the same species? *yes / no*
- The Bildstar and the Bintje are two varieties of potato.
If you cross the two potato varieties, will the following generation be fertile? Explain your answer.

2

Horses and donkeys can have offspring together. The offspring is then called a mule or a hinny. These animals are almost always infertile.

- Give one argument why a donkey and a horse are two different species.
- Give one argument why you could say they are the same species.

3

- a What is meant by 'variation'?
- b What is meant by 'selection'?
- c In a group of frogs of the same species, there are small variations among them: lighter or darker coloured, larger or smaller, with lots of spots or just a few. Explain what this has to do with evolution.

4



Summary

Make a summary of this Basics section. Complete the sentences and select the right words.

Organisms belong to the same species if:

-
- and

A species can consist of different (varieties) that *cannot* / *can* reproduce together.

The more similarities there are between two organisms, ...
.....

New species can arise through and
..... This is called

Species with a common ancestor are

The longer ago that common lived, the *greater* / *smaller* the degree of kinship between the species.

The more closely related the species are, the *more* / *less* similar their DNA will be.

INSIGHT

5

Read the text about the 'Liger'.

- a Give an argument for the statement that tigers and lions are two different species.
- b Give an argument for the statement that tigers and lions do belong to the same species.
- c What would the name be for the offspring of a male tiger and a female lion?
- d Why do ligers not occur in nature?

fig. 6

Liger

A liger is a cross between a male lion and a female tiger. In nature, lions and tigers do not occur in the same areas. The male ligers known so far have been infertile. Female ligers, however, are mostly fertile and able to reproduce with a tiger or a lion.



6

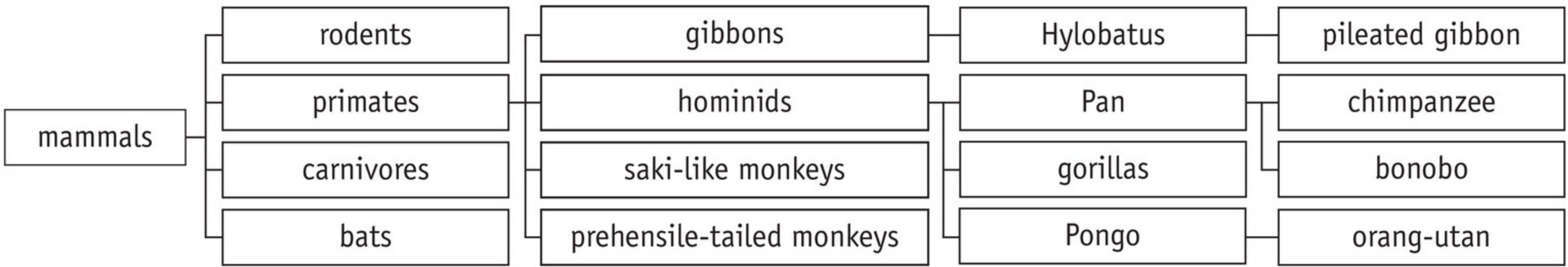
- a Which animal has greater kinship with a jaguar: a bat or a snake? Explain your answer.
- b Which organism is more closely related to a lion: a starfish or a toadstool? Explain your answer.

7

The chimpanzee, the bonobo, the orang-utan and the pileated gibbon are four apes. Figure 7 shows you a branching tree containing these apes. The bonobo, the orang-utan and the pileated gibbon are compared against the chimpanzee.

- a Which ape is most similar to the chimpanzee? And which is least closely related? Put the animals in the correct sequence.
- b Which animal is more similar to a chimpanzee: a bearded saki or a pileated gibbon? Or can't you tell that from the diagram in figure 7? Explain your answer.
- c Which animal is more closely related to a chimpanzee: a bearded saki or a hamster? Explain your answer.

fig. 7 Branching tree of the primates (apes, monkeys and prosimians)

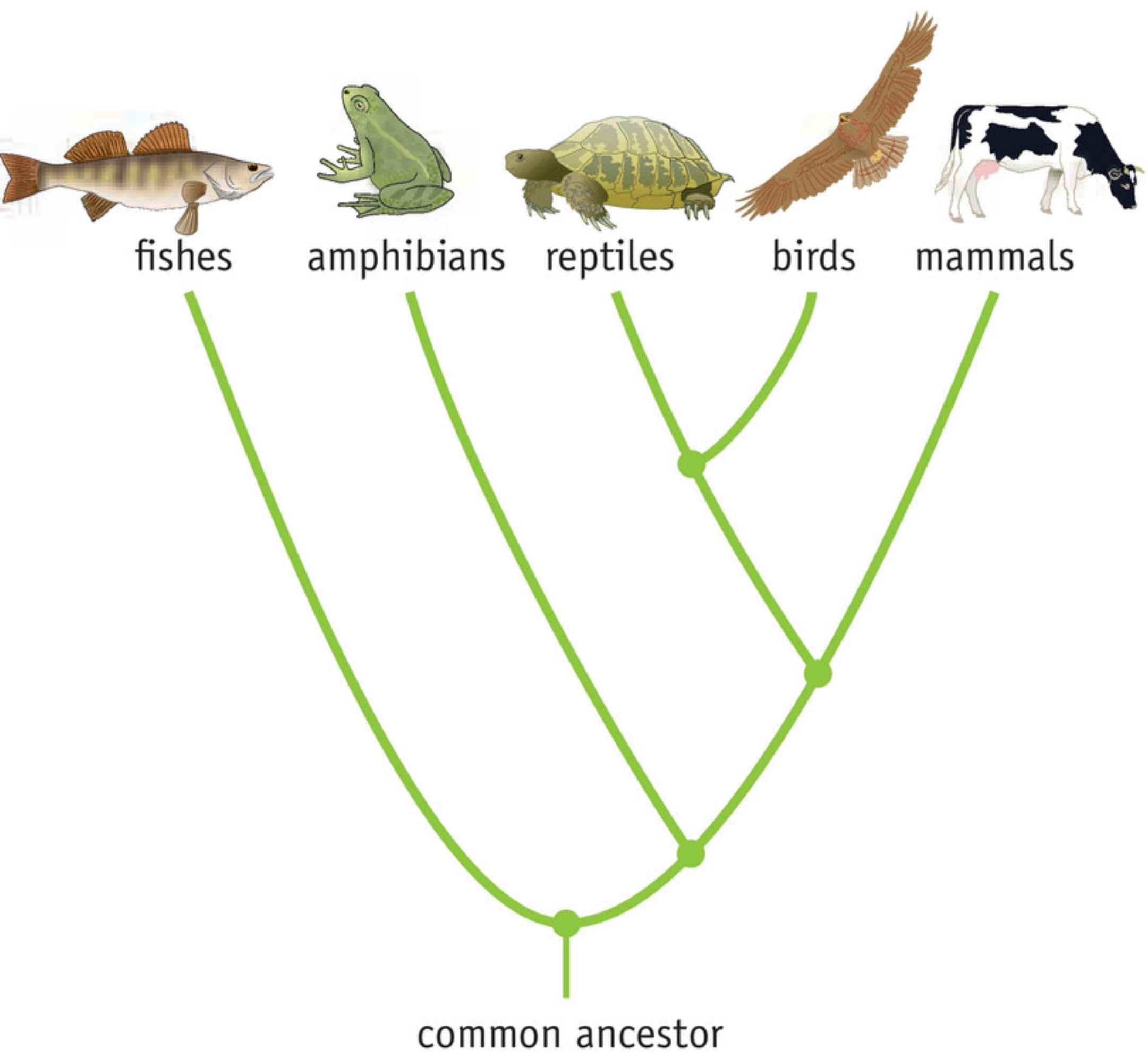


8

Figure 8 shows you a diagram with the ancestry of various groups of animals.

- a Which organisms are more closely related: reptiles and amphibians or reptiles and birds? Explain your answer.
- b Which organisms are more closely related: fishes and mammals or amphibians and mammals? Explain your answer.

fig. 8 A branching tree.



+ 9

Read the text about the ‘peppered moth’.

- a Explain why the darker variant of the peppered moth became more common during the Industrial Revolution.
- b Fifty years ago, the air quality started improving again and the trees’ bark became paler.
Which variant would become more common from that time onwards? Explain your answer.

fig. 9

Peppered moth

The peppered moth is a speckled white moth that birds eat. About a hundred and fifty to two hundred years ago, a darker variant appeared. During the Industrial Revolution, this rarer dark variant became increasingly common. Researchers think that this was because soot from industry coloured the birch bark darker.

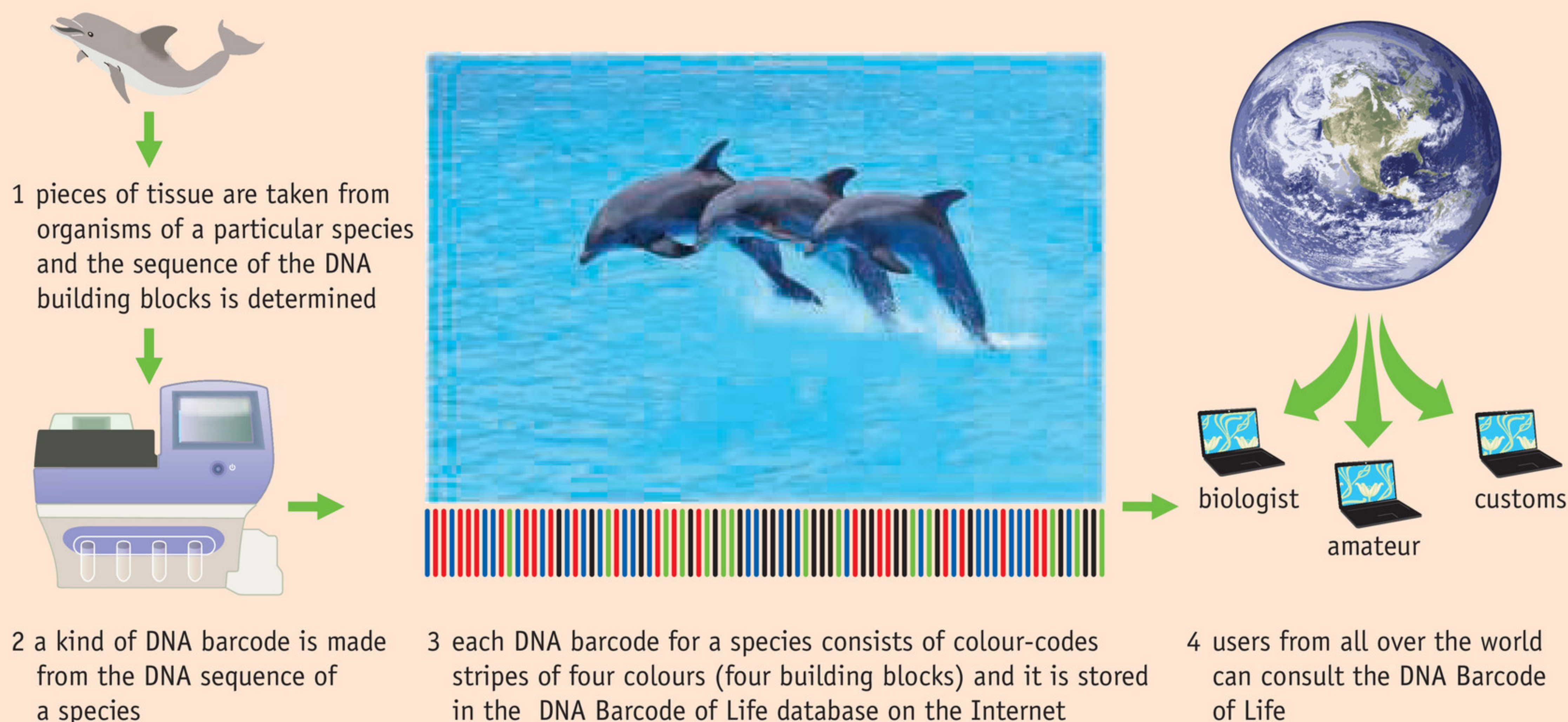


HOW IT FITS TOGETHER science

DNA SEQUENCING

Biologists throughout the world are attempting to produce a map of the DNA of all organisms. This research is called the DNA Barcode of Life. DNA sequencing (working out the sequence of bases in DNA) is becoming cheaper and quicker. For each kingdom, people are trying to investigate a fixed piece of DNA. Figure 10 shows you how this works.

fig. 10 DNA sequencing.



DNA sequencing is very useful for categorising organisms that are difficult or impossible to recognise – for a farmer with a plague of unknown insects in their crop, for instance, or for moulds in food. In the future, it may be possible to determine DNA sequences with a scanner device, so that answers can be given even more quickly.

10

Read the text on ‘DNA sequencing’.

All kinds of organisms live in ditches and pools. Researchers check what DNA can be found in ditches and pools several times a year. They only need the water for that because it contains dead cells of the organisms that live in it.

- a** How can DNA sequencing help investigate the species living in ditches and pools?
- b** A biologist is studying the brook lamprey, a rare and threatened fish that now only lives in a few streams in the East and South of the Netherlands.
Explain why research that only needs the water is very useful for this biologist.
- c** Will the DNA of a brook lamprey be more similar to the DNA of an eel or the DNA of the biologist? Explain your answer.
- d** Can a brook lamprey and an eel reproduce together?
- e** Explain how DNA sequencing can help study the degree of kinship between species.

 Go to the *Flash cards* and the *Test yourself* section.

3 Animals

LEARNING OBJECTIVES

- 3.3.6 You can classify animals based on the features ‘skeleton’ and ‘symmetry’.
- 3.3.7 You can list features and examples of six phyla of the animal kingdom.
- Practical activity 1

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	3.3.6	3.3.7	3.1.1*	3.1.2*
Remembering	2ab			
Understanding	1, 2c, 3c, 4, 6ab	3, 4, 6ab		
Using	5, 6c, 7a, 9a	5, 6c, 9a		
Analysing	6d, 7bc, 9b	8	9c	9cd

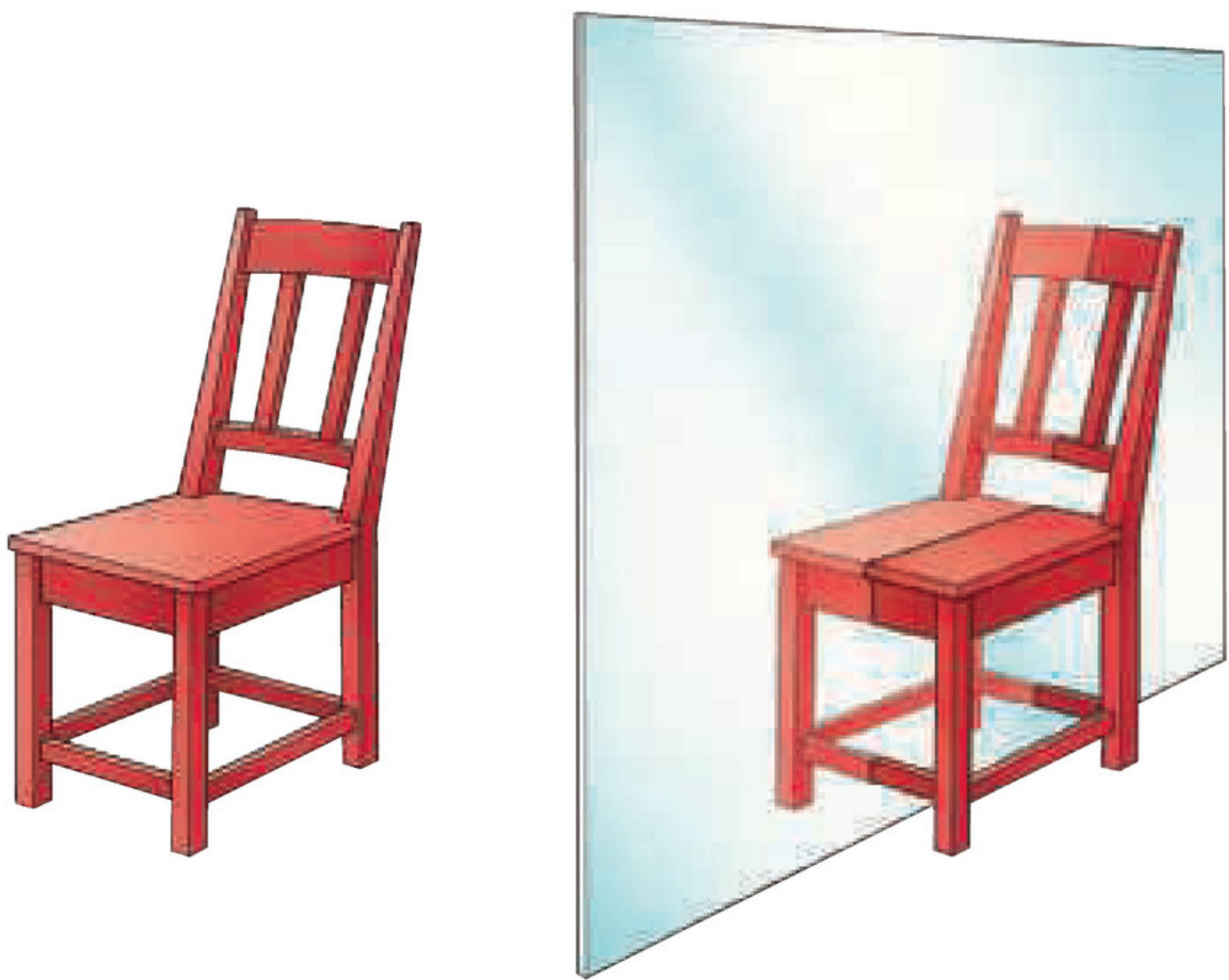
* You can find this learning objective in another unit.

More than 1.3 million animal species are known. Most of them are insects. Important features for the classification of animals are the symmetry and the skeleton.

SYMMETRY

Some objects have two halves that are mirror images of each other (see figure 1). Such objects are said to be **symmetrical**. A symmetrical object can be split into identical halves.

fig. 1 Symmetry.



- 1 This chair is symmetrical.
- 2 When matched up with its mirror image, half a chair makes a whole chair again.

The body layout of many organisms is symmetrical, although the halves are almost never exactly identical (see figure 2). The body of a human, for instance, looks pretty symmetrical on the outside. The organs inside are not symmetrical, however. The stomach is in the left-hand half of the torso and the liver on the right. Even so, biologists say that a human is symmetrical.

fig. 2 Symmetrical?



1 photo of a face

2 the left half of the face
plus its reflection

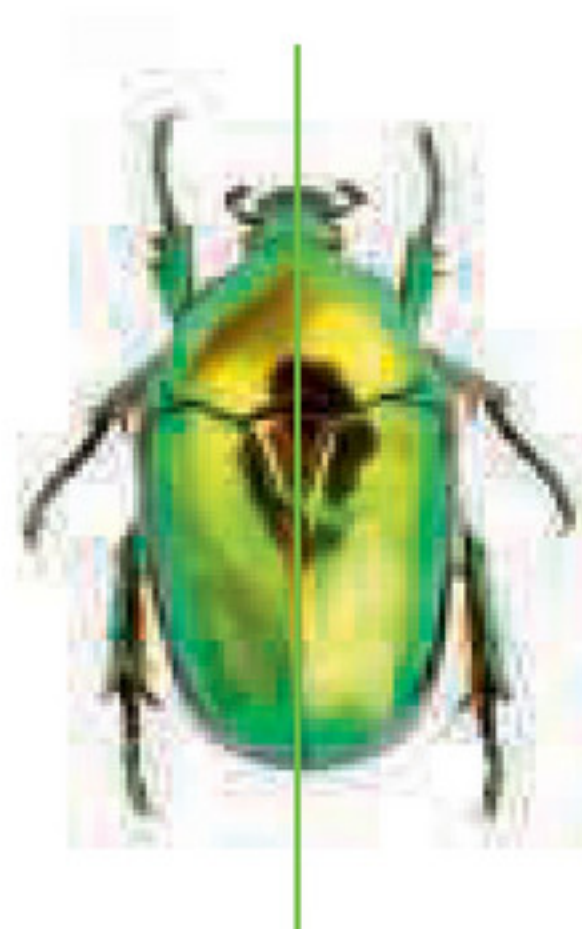
3 the right half of the face
plus its reflection

Many species of animals have **bilateral symmetry**. That means that there is only one line you could split them into two identical halves along. A beetle is an example (see figure 3.1).

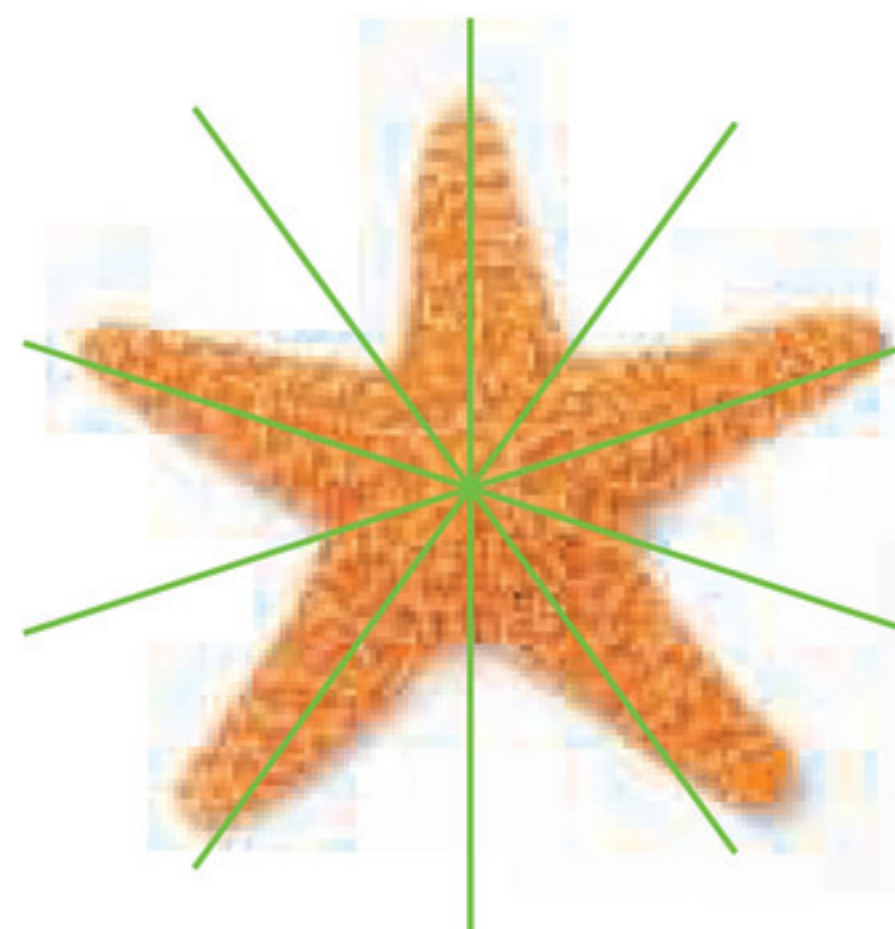
Other species of animals have **radial symmetry**. These animals could be split into equal halves in lots of ways (see figure 3.2).

When there is no way that an animal could be split into two identical halves, it is said to be **asymmetric** (see figure 3.3).

fig. 3 Symmetry in animals.



1 beetle: bilateral
symmetry



2 starfish: radial
symmetry



3 red finger sponge:
asymmetric

SKELETON

Many animals have rigid structures in or around their bodies. These rigid parts of the animal are its **skeleton**. The skeleton provides rigidity and protection.

Figure 4 shows you various types of skeletons. A mussel, a snail and a ladybird all have the skeleton on the outside of the body. This is called an **exoskeleton** or **external skeleton**. A sponge, a cuttlefish and a human all have the skeleton on the inside of the body. This is called an **endoskeleton** or **internal skeleton**.

fig. 4 Skeletons in animals.

- 1 internal skeleton of a sponge: tough fibres of keratin between the cells



- 2 external skeleton of a mussel: a shell (two pieces)



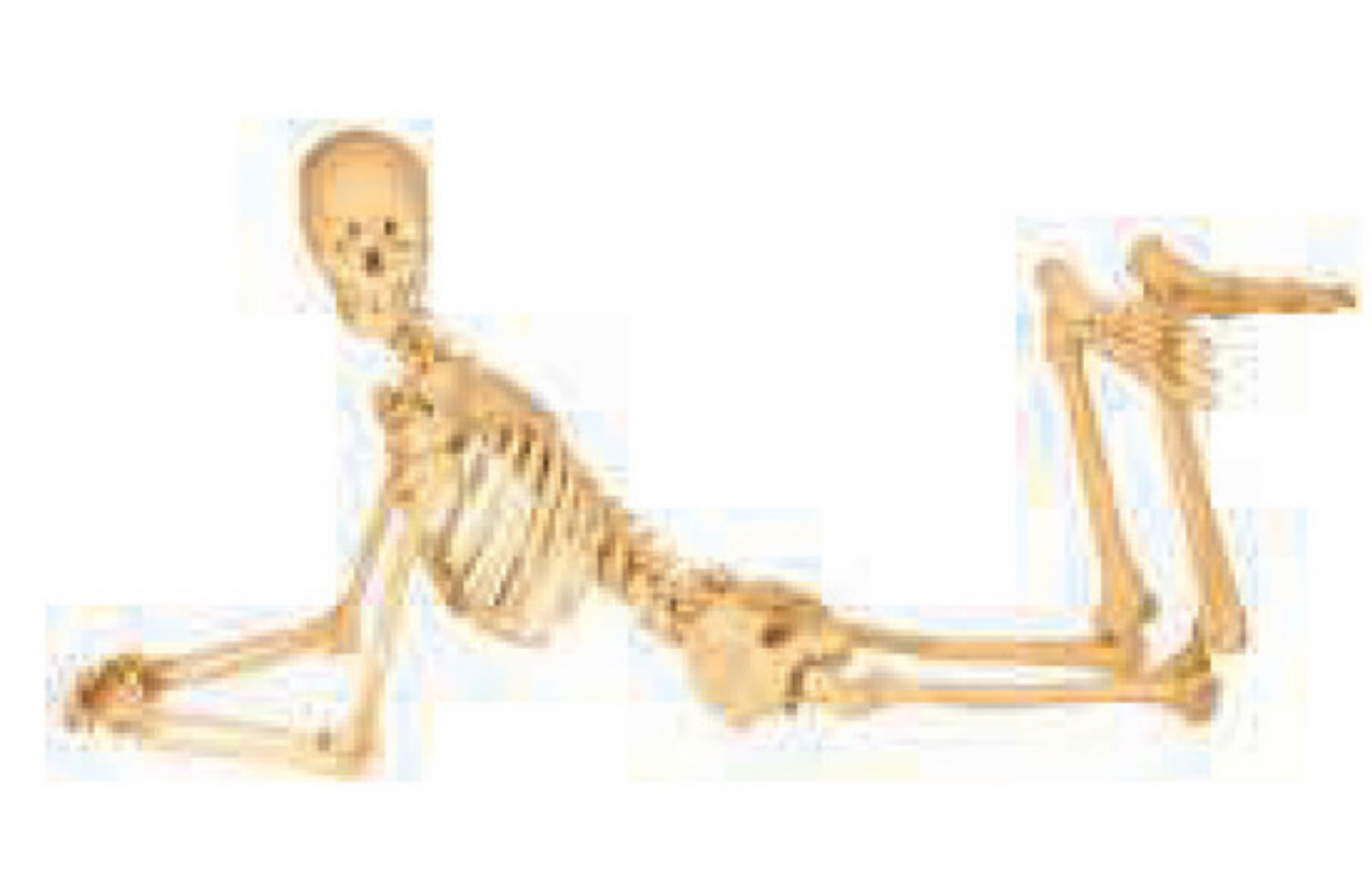
- 3 external skeleton of a snail: a shell (one piece)



- 4 internal skeleton of a cuttlefish: an internal shell (cuttlebone)



- 5 external skeleton of a ladybird: exoskeleton armour

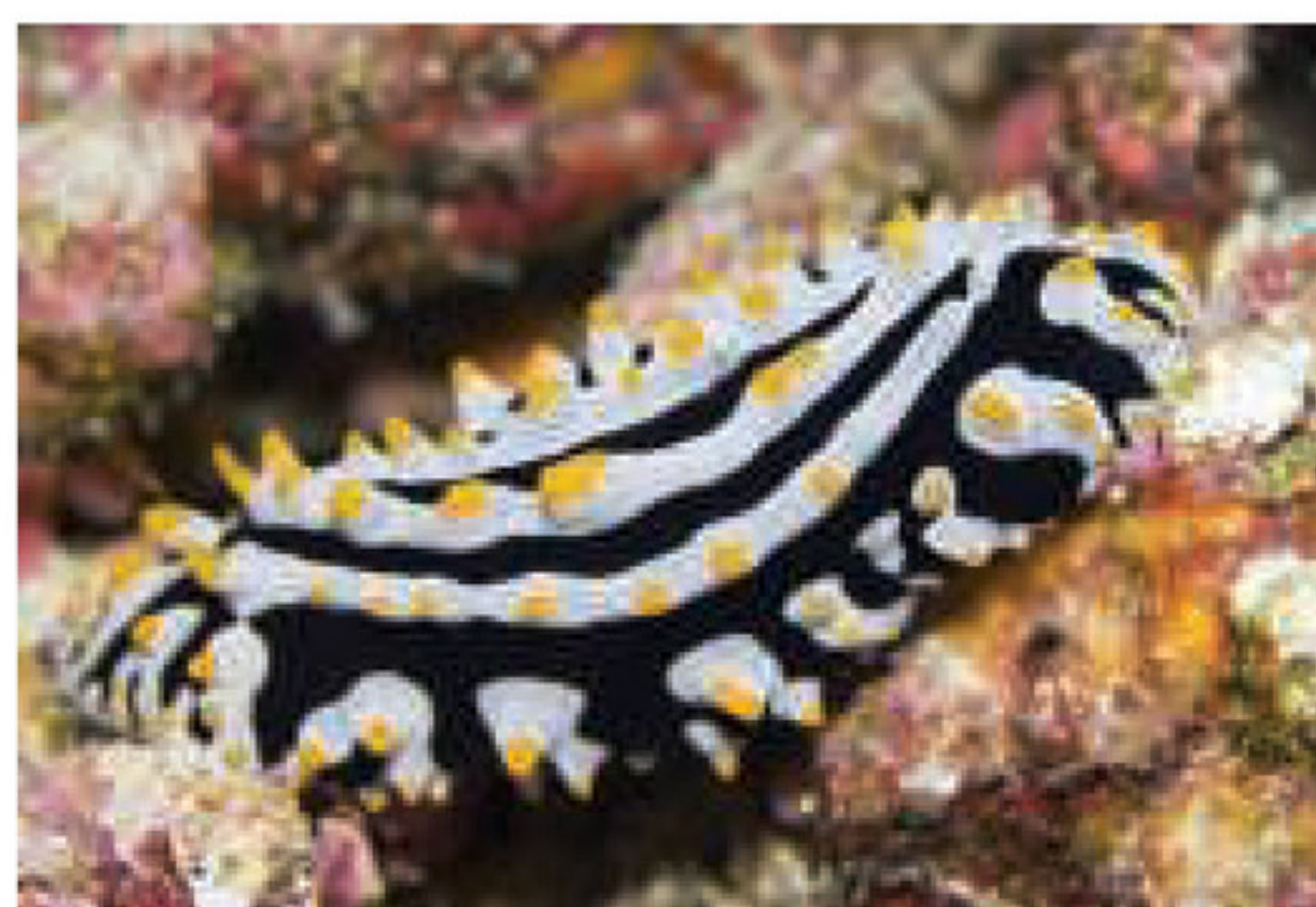


- 6 internal skeleton of a human: an endoskeleton of bones

There are also animals that have no skeleton (see figure 5). Animals without skeletons mostly live in water.

fig. 5 Animals with no skeletons.

- 1 sea anemone



- 2 sea slug

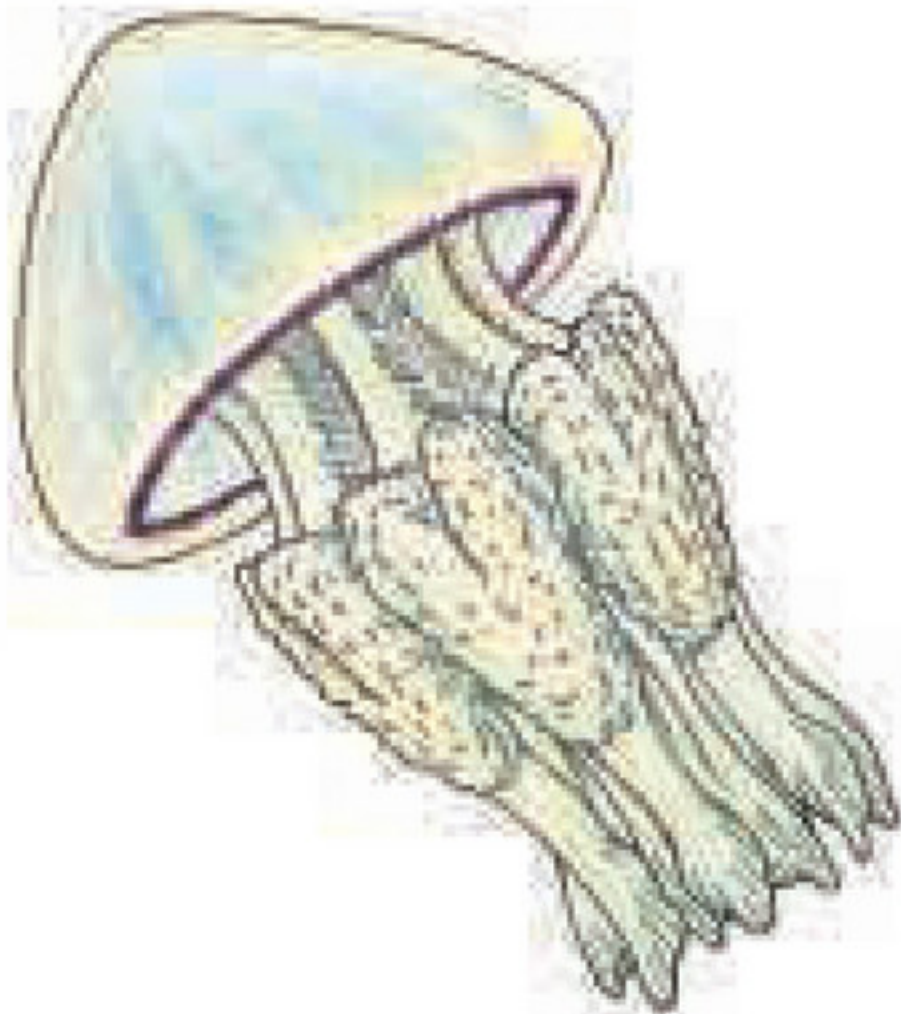
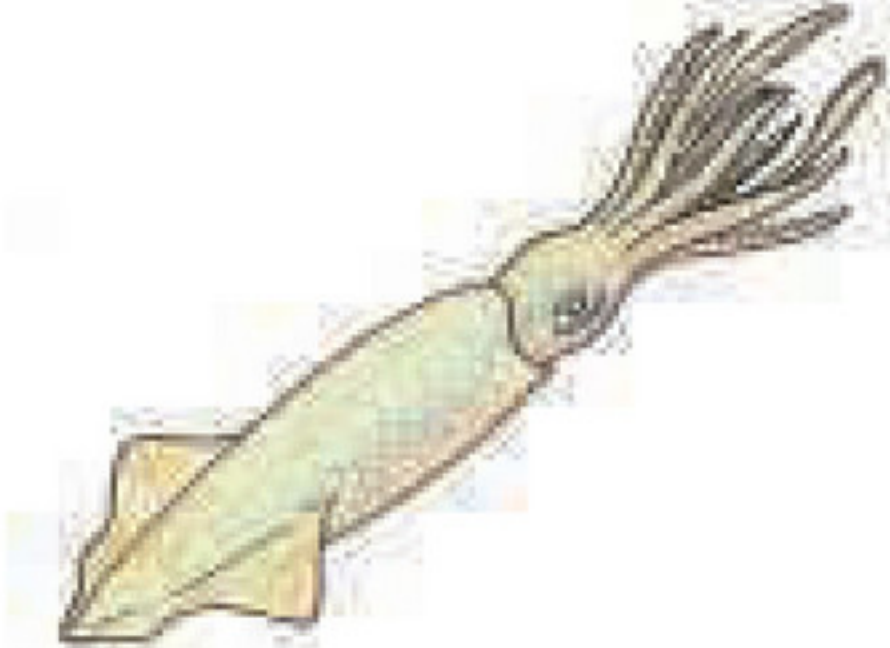
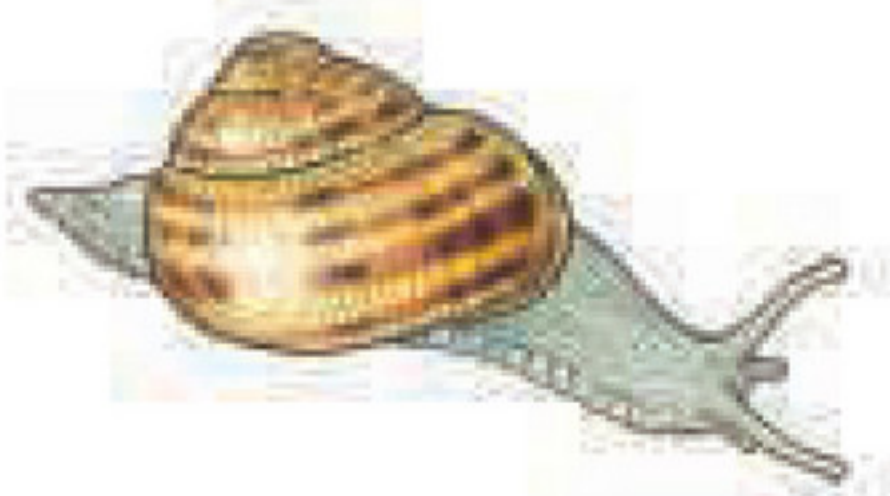
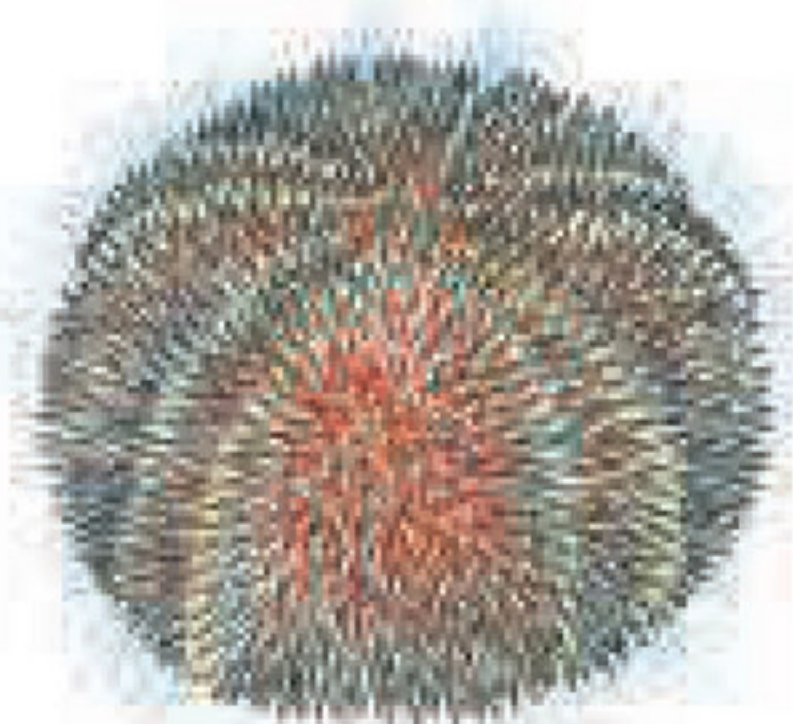
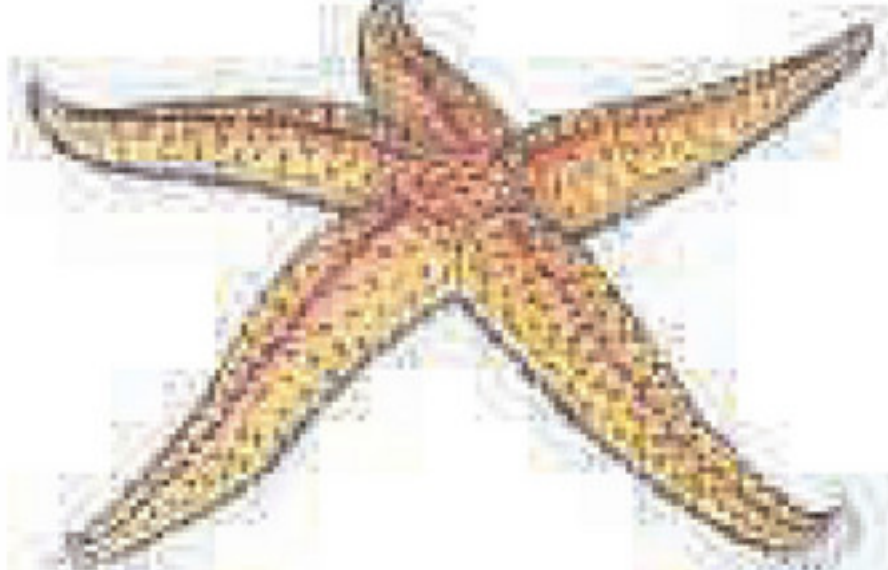


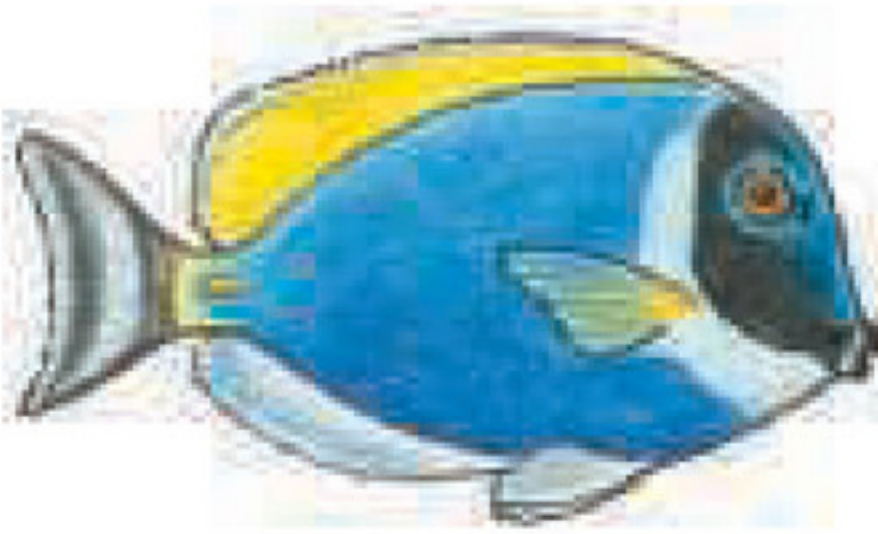
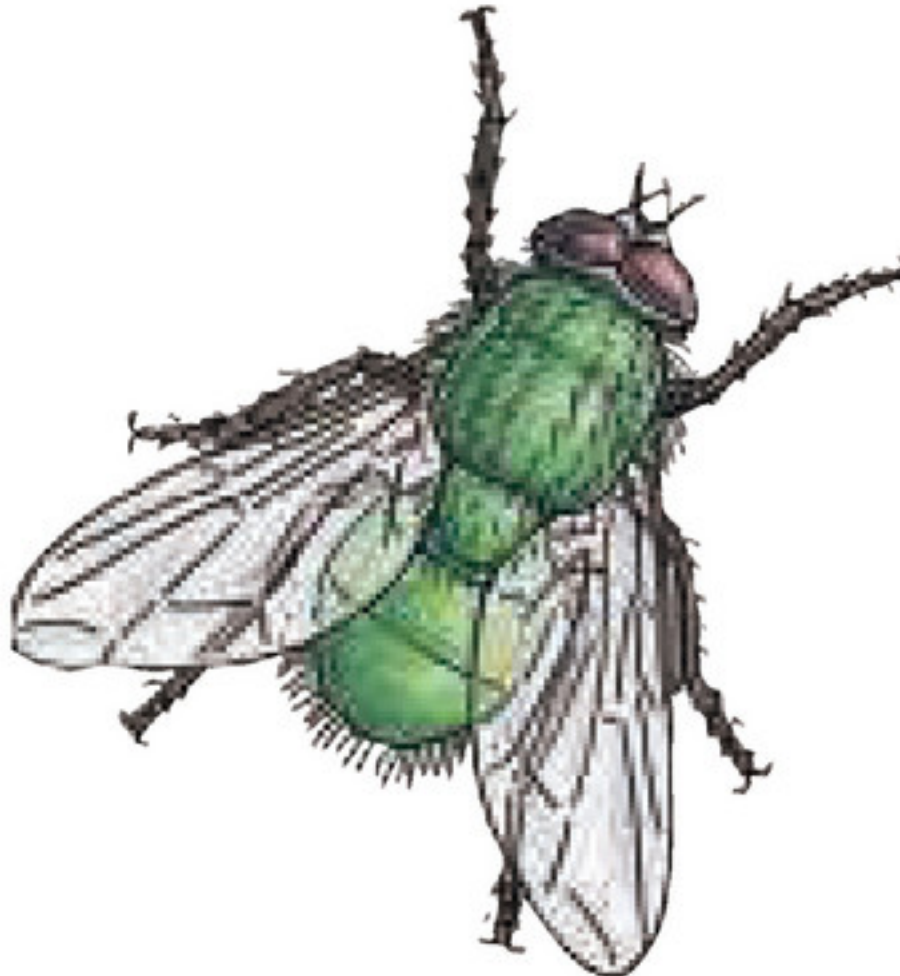
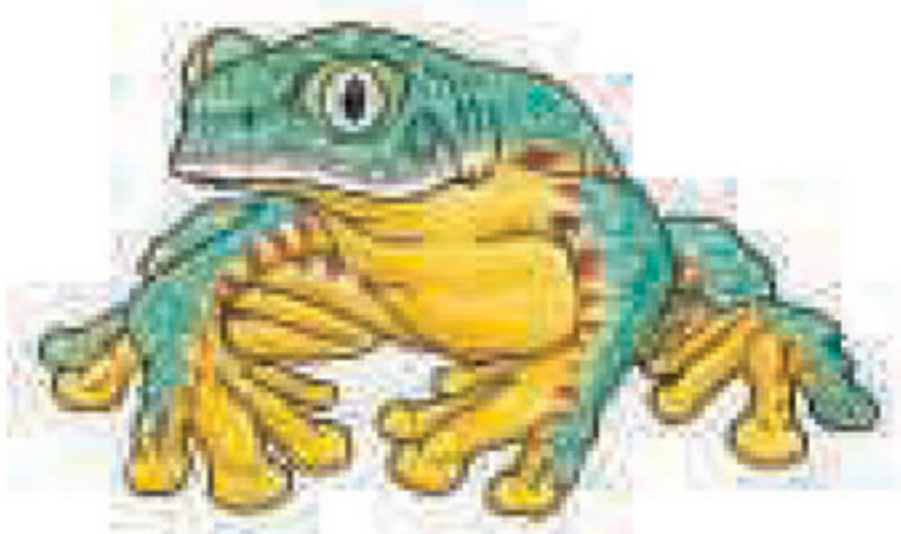
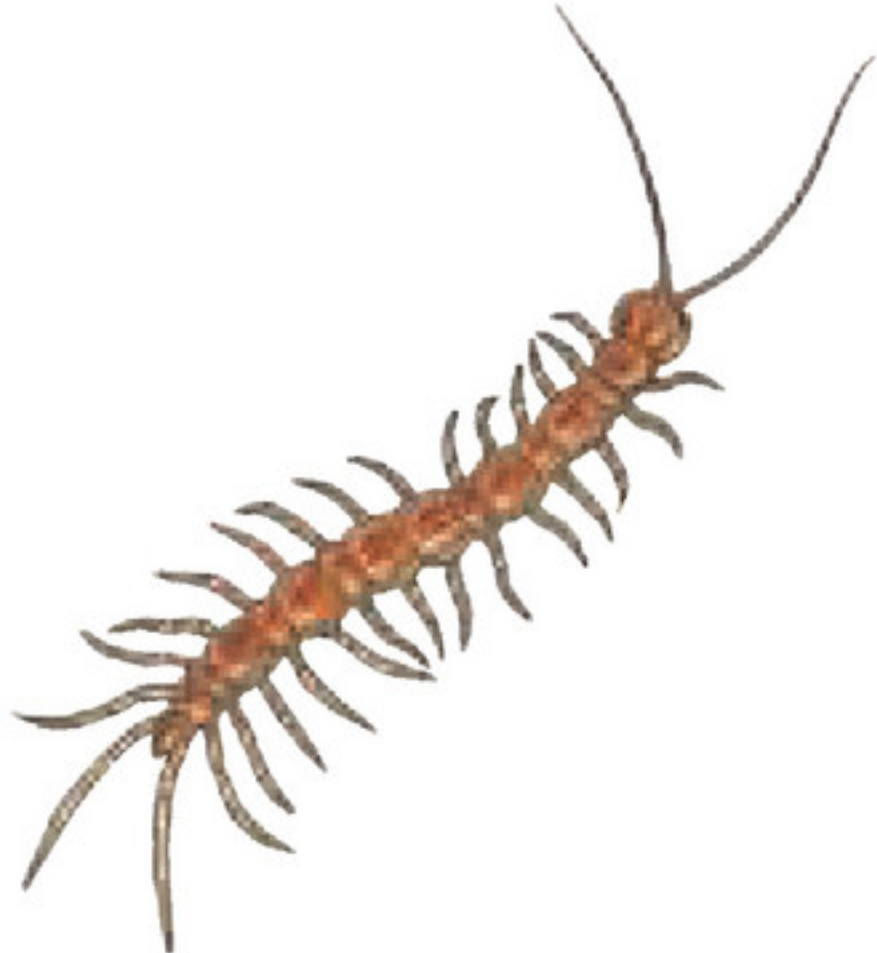
- 3 jellyfish

CLASSIFICATION OF ANIMALS

Important features for the classification of animals are the symmetry and the skeleton. Animals are classified into 34 phyla. Those include sponges, cnidarians, molluscs, echinoderms, arthropods and vertebrates. Figure 6 shows you those phyla and their features. For each phylum, several animals have been drawn as examples. A number of classes of arthropods and vertebrates have been given as examples.

fig. 6 Some phyla of the animal kingdom.

1 SPONGES Features: • asymmetrical • tough keratin fibres between the cells • are mostly fixed in place on the seabed  yellow tube sponge purple tube sponge	2 CNIDARIANS Features: • radially symmetrical • do not generally have a skeleton • live in water • catch their prey with tentacles  jellyfish sea anemone
3 MOLLUSCS Features: • bilaterally symmetrical • generally have a shell as a skeleton  mussel squid  sea slug snail	4 ECHINODERMS Features: • radially symmetrical • internal skeleton of calcium carbonate • the skin is covered with spines or nodules • live on the seabed  starfish sea urchin  sea cucumber

5 ARTHROPODS	6 VERTEBRATES
Features: - bilaterally symmetrical - the skeleton is a protective cuticle	Features: - bilaterally symmetrical - an internal skeleton
ARACHNIDS  spider	BONY FISH  surgeonfish
INSECTS  fly	AMPHIBIANS  tree frog
HIGHER CRUSTACEANS  crab	REPTILES  sand lizard
CENTIPEDES  centipede	MAMMALS  badger

KNOWLEDGE

1

Figure 7 shows you drawings of a desk lamp, a sponge and a swallow.

a Which of these are symmetrical?

- ☐ A desk lamp
- ☐ B sponge
- ☐ C swallow

b Figure 8 shows you two drawings of a crocodile.

A crocodile is *not* / *bilaterally* / *radially* symmetrical.

c Which parts of a crocodile are mirror images of each other?

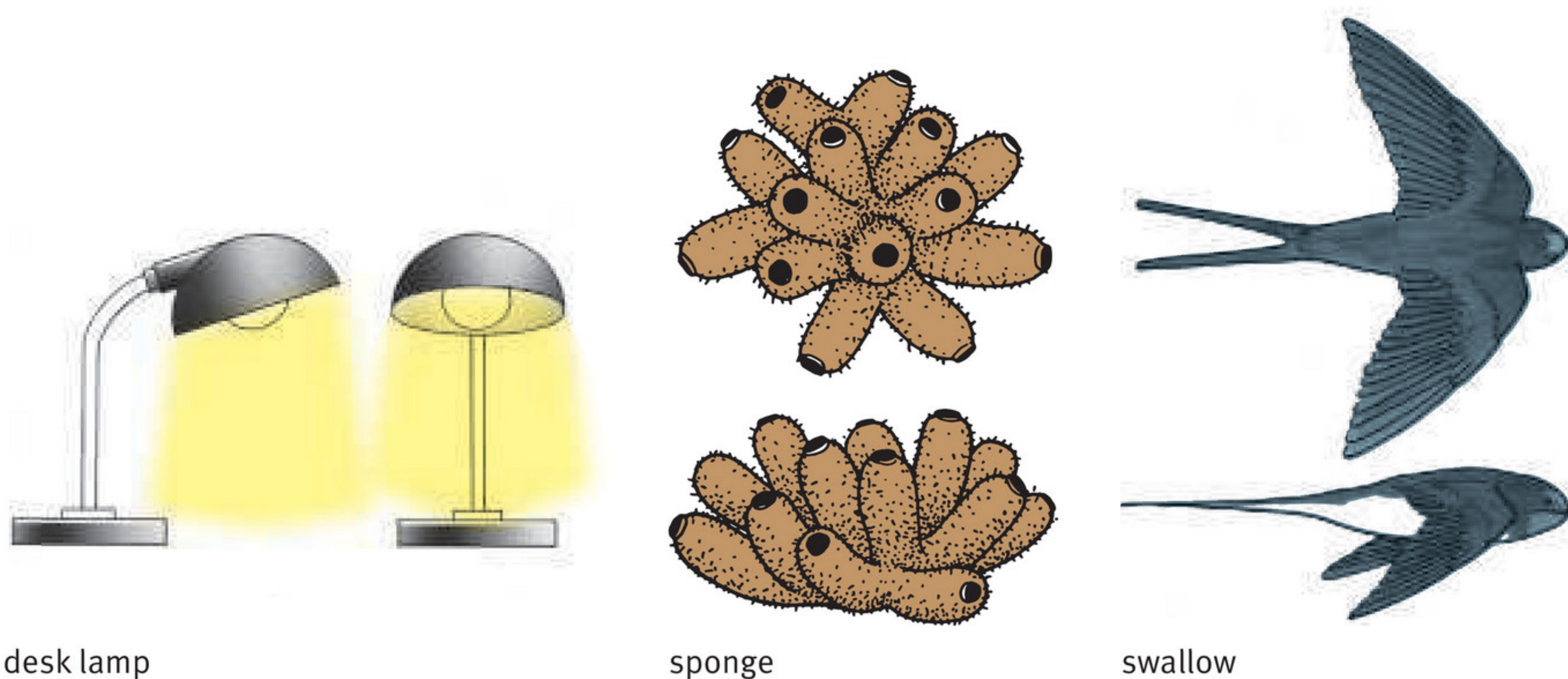
- ☐ A The left and right sides
- ☐ B the top and bottom

d Figure 9 shows you a top view of the skeleton of a sea urchin.

A sea urchin is *not* / *bilaterally* / *radially* symmetrical.

e A human is *not* / *bilaterally* / *radially* symmetrical.

fig. 7

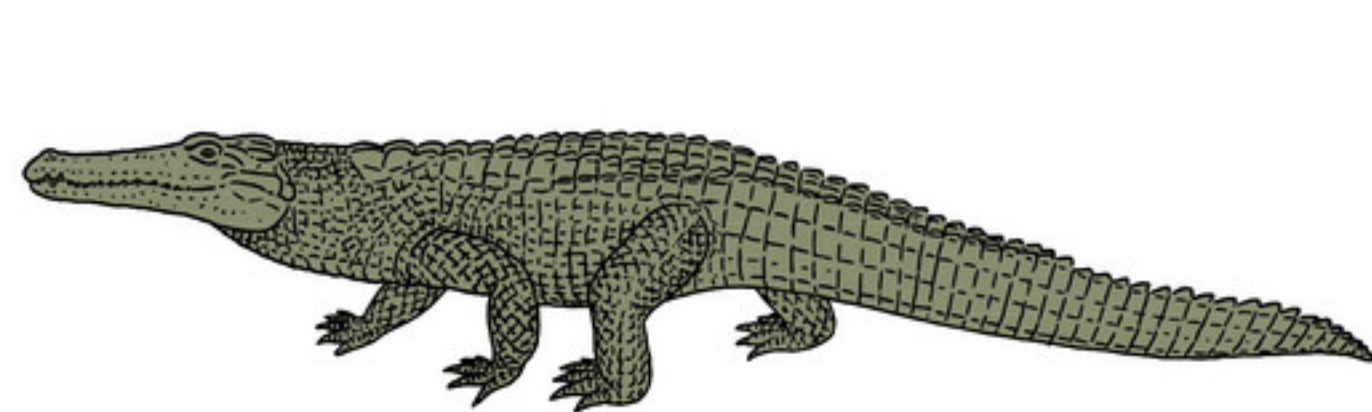


desk lamp

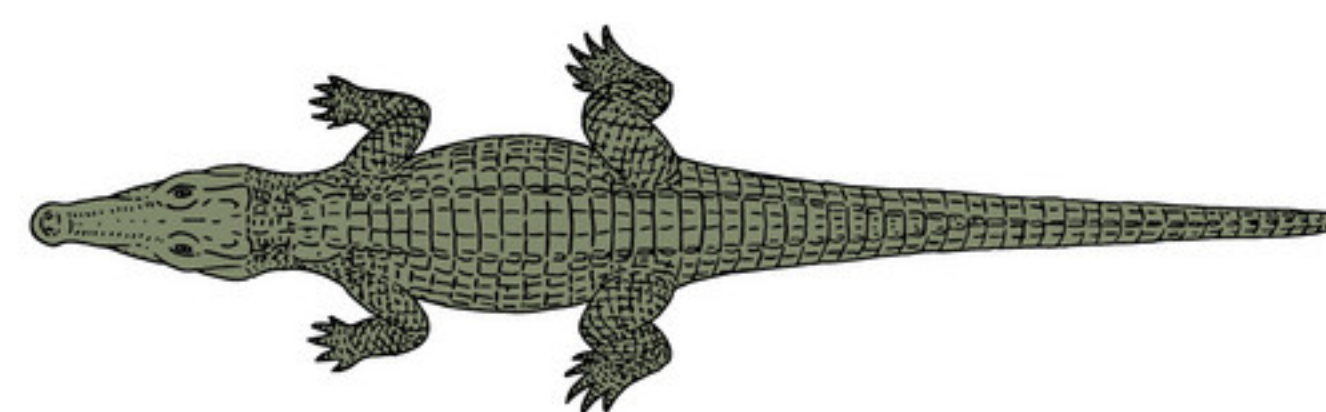
sponge

swallow

fig. 8 Crocodile.



1 side view



2 top view

fig. 9 Sea urchin.



1 top view



2 skeleton

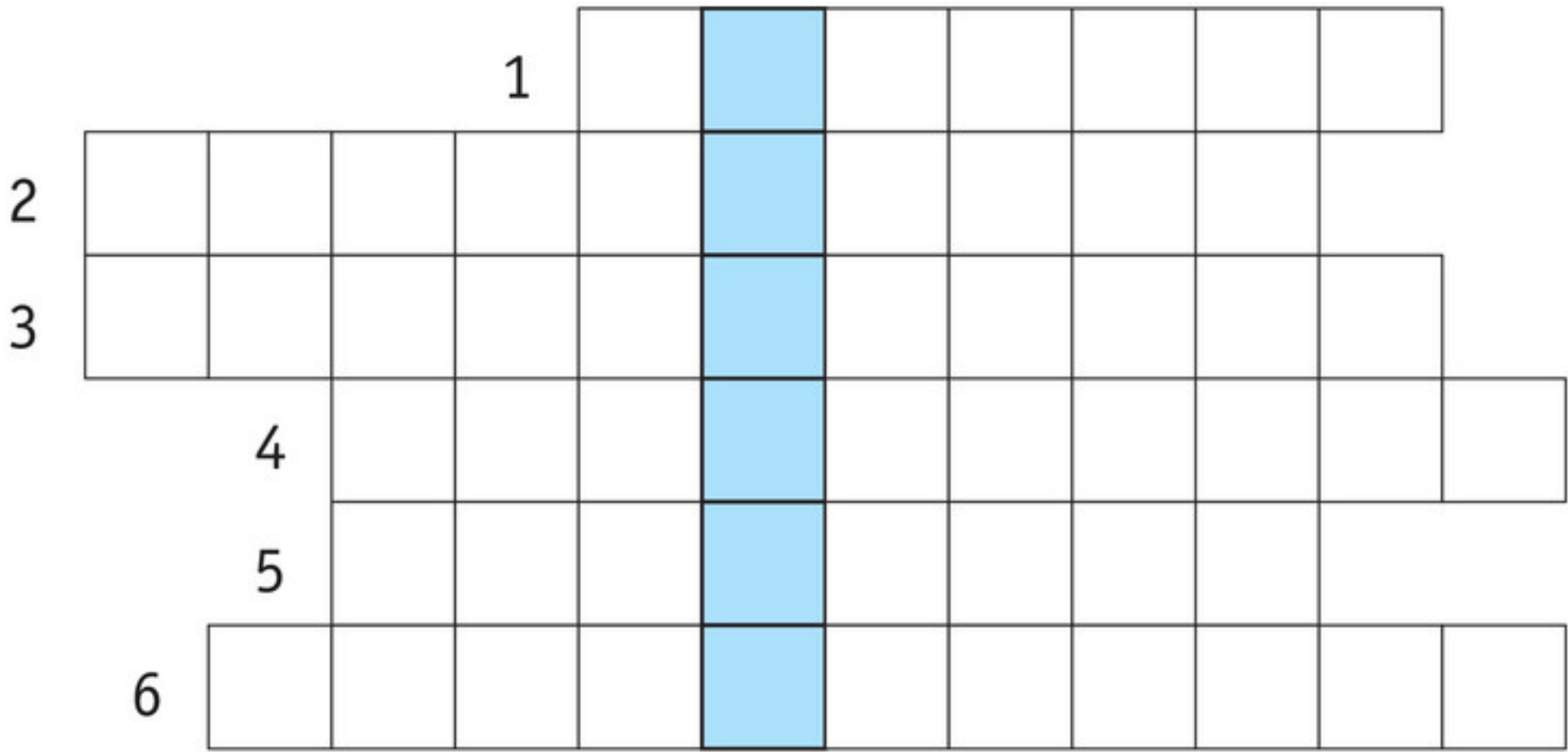
2

- a What is the function of a skeleton?
-
- b Does a sea urchin have an internal skeleton or an external skeleton?
an internal skeleton / an external skeleton
- c Does an ant have an internal skeleton or an external skeleton?
an internal skeleton / an external skeleton

3

- Descriptions of the six phyla from figure 6 are given below.
- a Complete the phyla in the puzzle in figure 10.
- 1 asymmetrical animals
 - 2 animals with armour as an external skeleton
 - 3 radially symmetrical animals with a chalky skeleton
 - 4 animals with tentacles but no skeletons
 - 5 animals with shells
 - 6 Bilaterally symmetrical animals with an internal skeleton
- b You can see the name of an animal in the blue squares.
Which phylum of the animal kingdom does this animal belong to?
- c What features are used for classifying animals into phyla?

fig. 10 Puzzle



4



- Summary**
- Make a summary of this Basics section.
- Make schematic drawings of the three types of symmetry.
 - Complete the table.

Phylum	Symmetry	Skeleton
Arthropods		
Vertebrates		
Cnidarians		
Sponges		
Echinoderms		
Molluscs		

INSIGHT

5

There are nine photos of animals in figure 11.
Put the correct phylum by each animal.

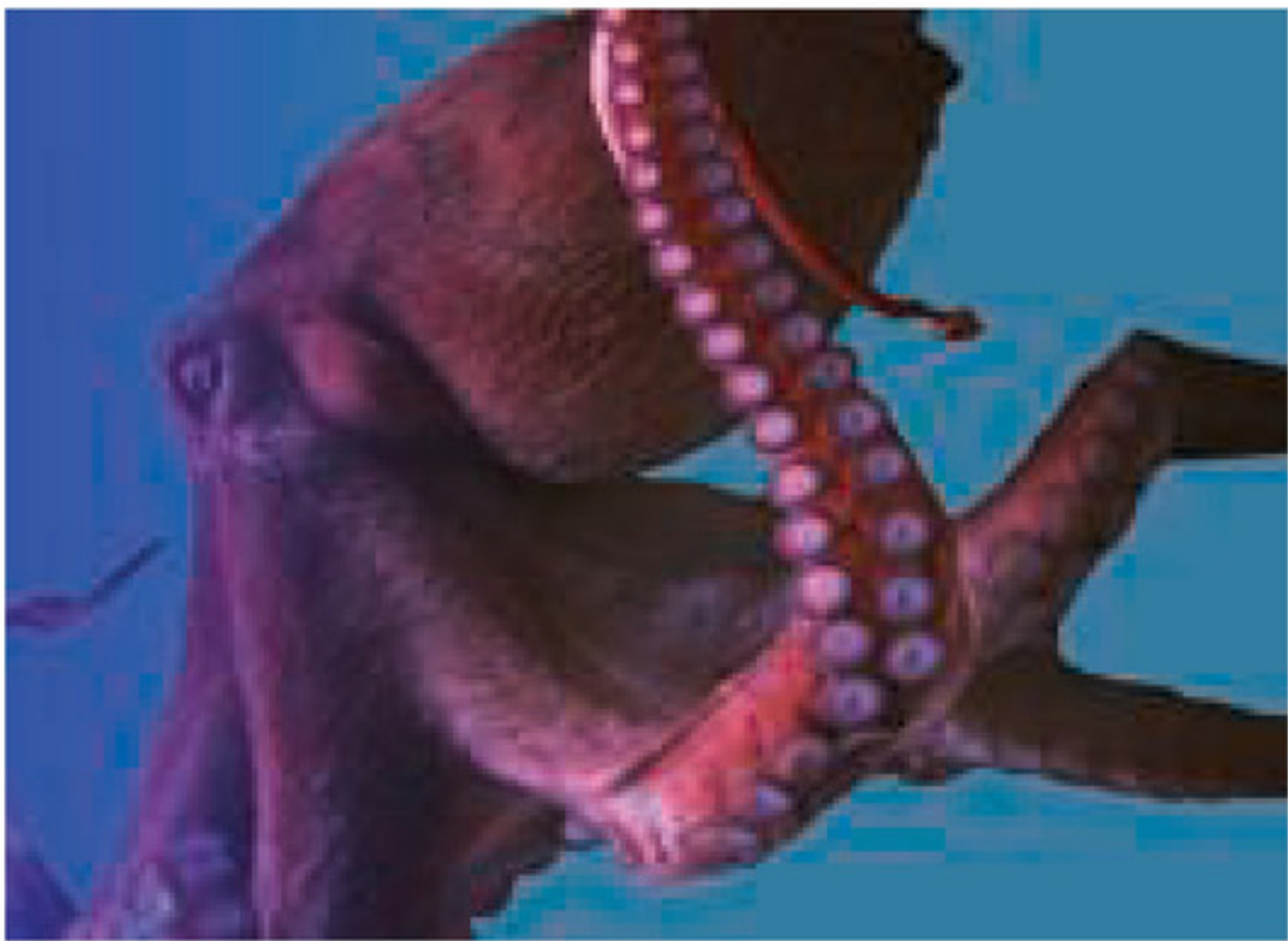
fig. 11 Nine animals.



1



2



3



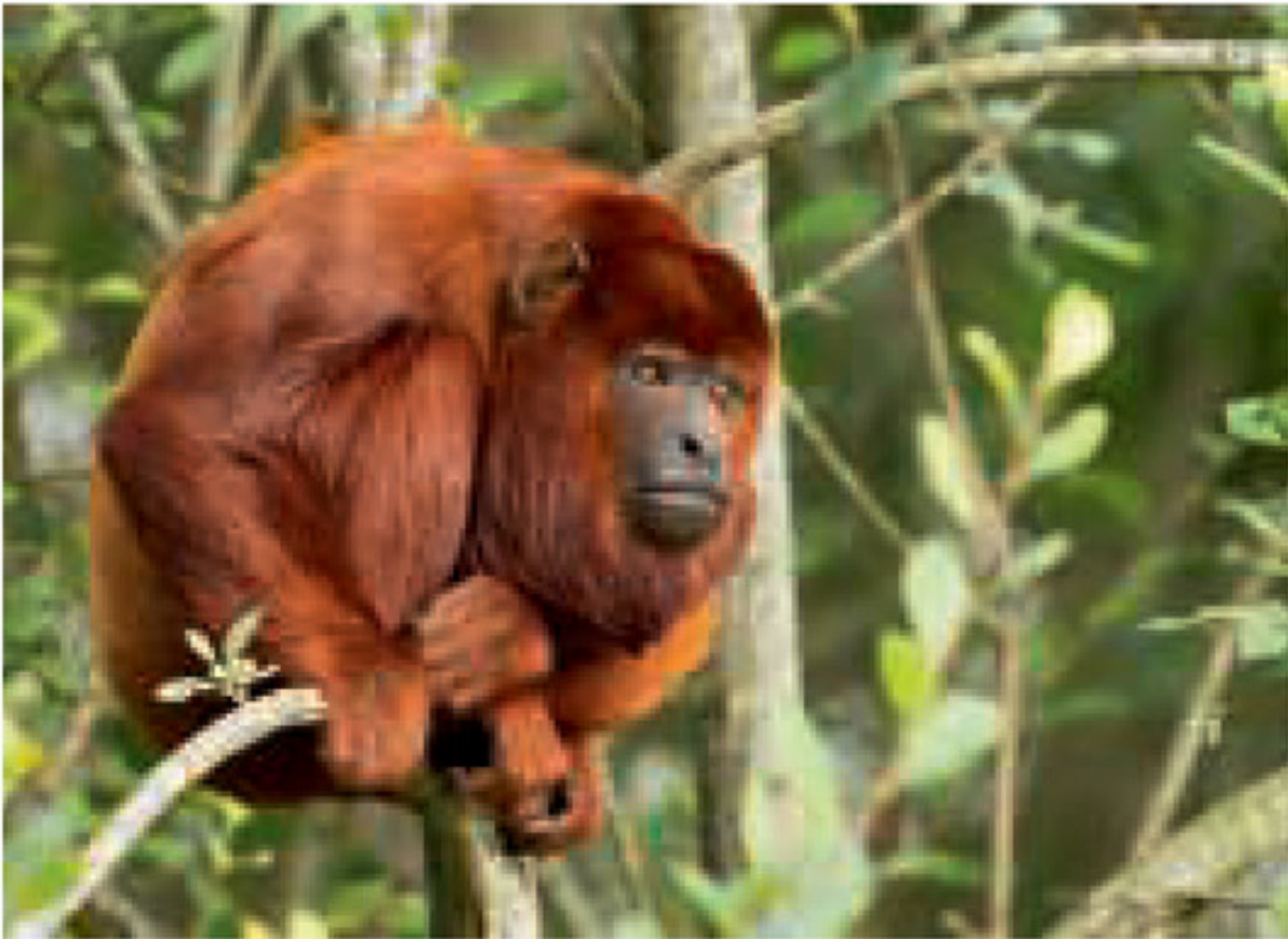
4



5



6



7



8



9

6

Figure 12 shows you a hermit crab.

- a** What kind of skeleton does a hermit crab have?
- b** What phylum does a hermit crab belong to?
- c** The hermit crab lives in the empty skeleton of another animal.
What phylum does that animal come from?
- d** What is the function of the empty skeleton for a hermit crab?

fig. 12 Hermit crab.



7

Slugs are like snails without shells.

- a** Do slugs have an internal skeleton? *yes / no*
- b** One function of the skeleton is protection.
What two factors do slugs have no protection against?
- c** Why are slugs more active when it has been raining or when the ground is wet?

+ 8

Sponges are fixed to the seabed.

Explain why many sponges are poisonous.

HOW IT FITS TOGETHER the living world

CORAL

A coral is an animal. Or in fact, lots of animals: on the surface of a piece of coral, there is a huge colony of thousands of polyps. The bodies of these coral residents have a series of protrusions at the top that the polyp uses as a kind of arm for catching small prey animals (see figure 13).

fig. 13 A coral reef near the Philippines, with polyps.



At the bottom of the body of the polyp, chalky substances are secreted (passed outside the body) that make up the skeleton on the coral. This continuous secretion of limestone makes a healthy coral reef grow, slowly but surely. The limestone-like coral acts as a common skeleton for the whole polyp colony.

The polyps live together with microalgae, single-celled organisms with chloroplasts. The algae live in the tissue of the animal. They make nutrients by photosynthesis that they share with the coral cells. This means that the algae are an important food source for the coral polyps. The coral in turn excretes ammonium as a waste product, which is an important nutrient for the algae.

After: *Symbiosis between alga and coral is as old as the dinosaurs*, Artis Micropia, 2016.

9

Read the text about 'Coral'.

- a What phylum do the polyps that live on the coral belong to? Explain your answer.
- b Does a polyp have an internal or an external skeleton? Explain your answer.
- c The microalgae that live in the coral belong to a group called *dinoflagellates*.
Dinoflagellates are not plants.
So what kingdom do they belong to? Explain your answer.
- d Tropical coral reefs only occur in shallow water.
Explain why.

 Go to the *Flash cards* and the *Test yourself* section.

4 Plants

LEARNING OBJECTIVES

- 3.4.8 You can classify plants into eight phyla.

3.4.9 You can name the features of vascular plants and green algae and you can give examples of them.

3.4.10 You can name the features of spore-bearing plants and seed plants and you can give examples of them.
- Learning how to do research 1 and 2

► Practical activities 2 and 3

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	3.4.8	3.4.9	3.4.10	3.1.2*
Remembering	1	2ab, 3a	3a	
Understanding	6	2c, 3b, 6, 10a	3bc, 4, 5	10a
Using	7, 8abc, 10c	10bc	8bc	10b
Analysing	9	8d	8d	10d

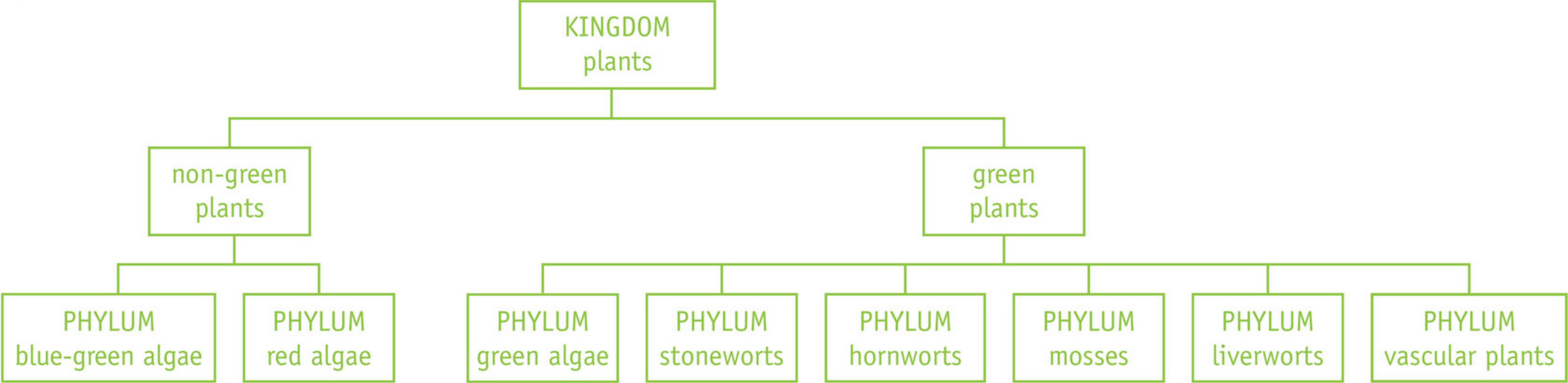
* You can find this learning objective in another unit.

Plants live everywhere on Earth, in some of the most difficult conditions. Plants even grow in the deserts. More than 390,000 species of plants have been discovered.

CLASSIFICATION OF PLANTS

Biologists look at various features when classifying plants, such as the type of chloroplasts, the structure of the plant and the way the cell organelles function. Figure 1 is a simplified diagram of how plants are classified. Two of the phyla are green algae and vascular plants. You can read more about these phyla in the basics.

fig. 1 Classification of plants.

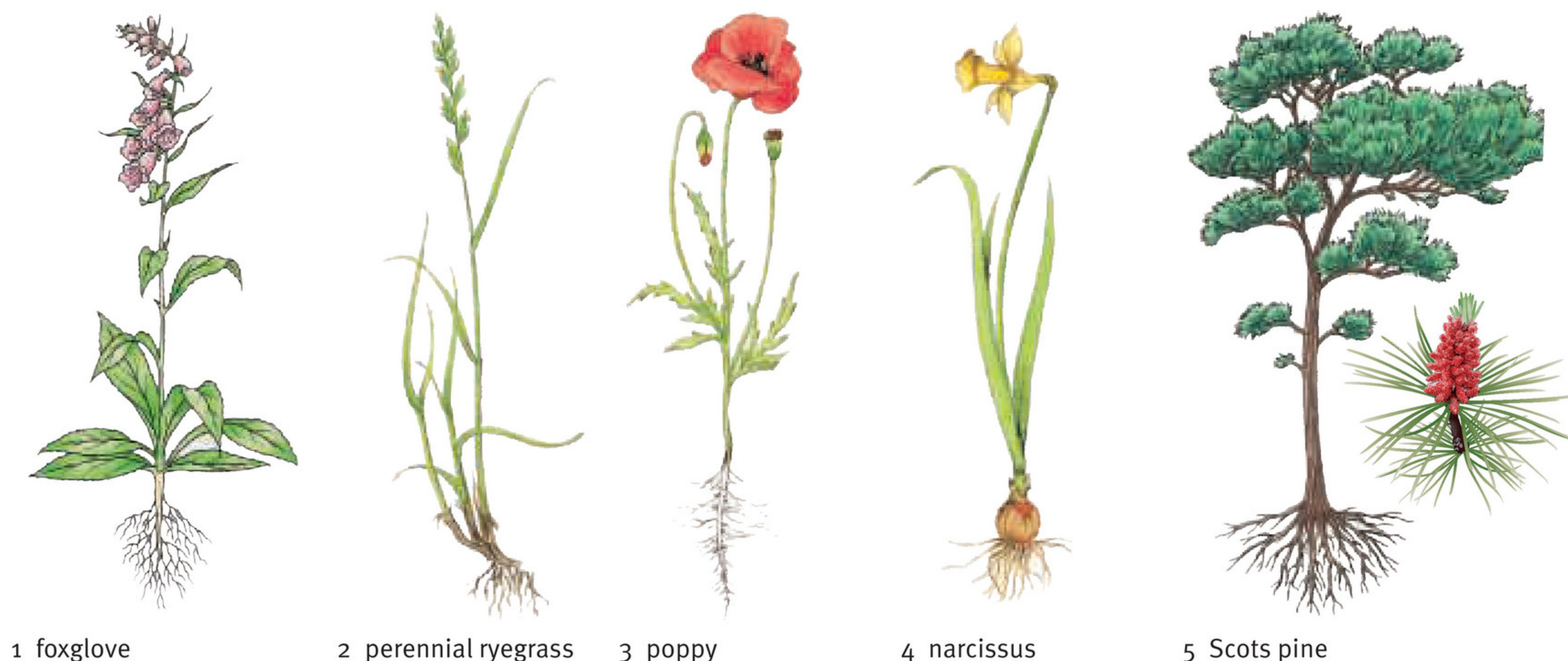


VASCULAR PLANTS

Most of the plants you know are **vascular plants**. Those are plants that have vessels inside for transporting substances. They are plants with stems, roots and leaves. Many vascular plants produce seeds that can grow to produce new plants. There are other vascular plants that reproduce using spores. A **spore** is a cell that can grow into a new plant.

Seed plants have roots, stems, leaves and flowers (see figure 2). They reproduce through seeds that are produced in the flowers. Seed plants include plants like daisies and buttercups, as well as shrubs and trees. All seed plants belong to the phylum of vascular plants.

fig. 2 Seed plants have roots, stems, leaves and flowers.



SPORE-BEARING PLANTS

Spore-bearing plants (also known as cryptogams) can have roots, stems and leaves but do not have flowers. Horsetails and ferns are vascular plants that reproduce using spores. Mosses and some algae also reproduce through spores.

Mosses are small plants that are found together in groups (see figure 3.1). The leaves of mosses are very small. The spores are produced in spore capsules that protrude above the moss plants (see figure 3.2).

fig. 3 Common hair moss.



1 Moss plants grow in groups together.

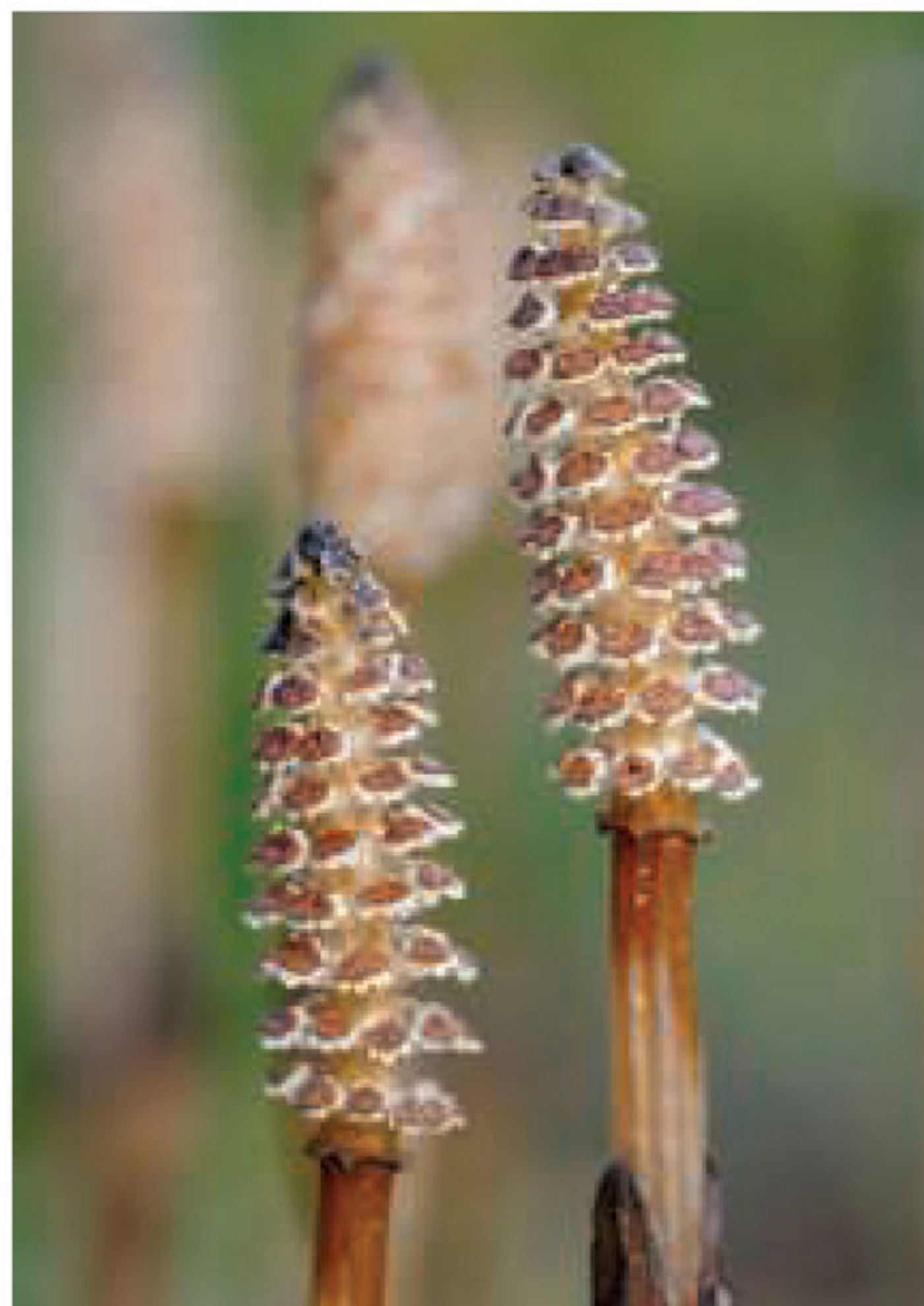
2 spore capsules on stalks

Horsetails are made up of a kind of ‘tube’ that you can pull sections off one by one (see figure 4.1). The spores are made in spore-producing organs on the ends of some stems (see figure 4.2).

fig. 4 Field horsetail.



1 Horsetails are made up of tube sections.



2 spore-producing bodies on the ends of the stems

You can recognise ferns from the big leaves that are made up of lots of small leaves attached to a main vein (see figure 5.1). The spores are produced in sporangia (singular: sporangium) on the undersides of the small leaves (see figure 5.2).

fig. 5 Male fern.



1 The leaves of a fern are made up of smaller leaves.



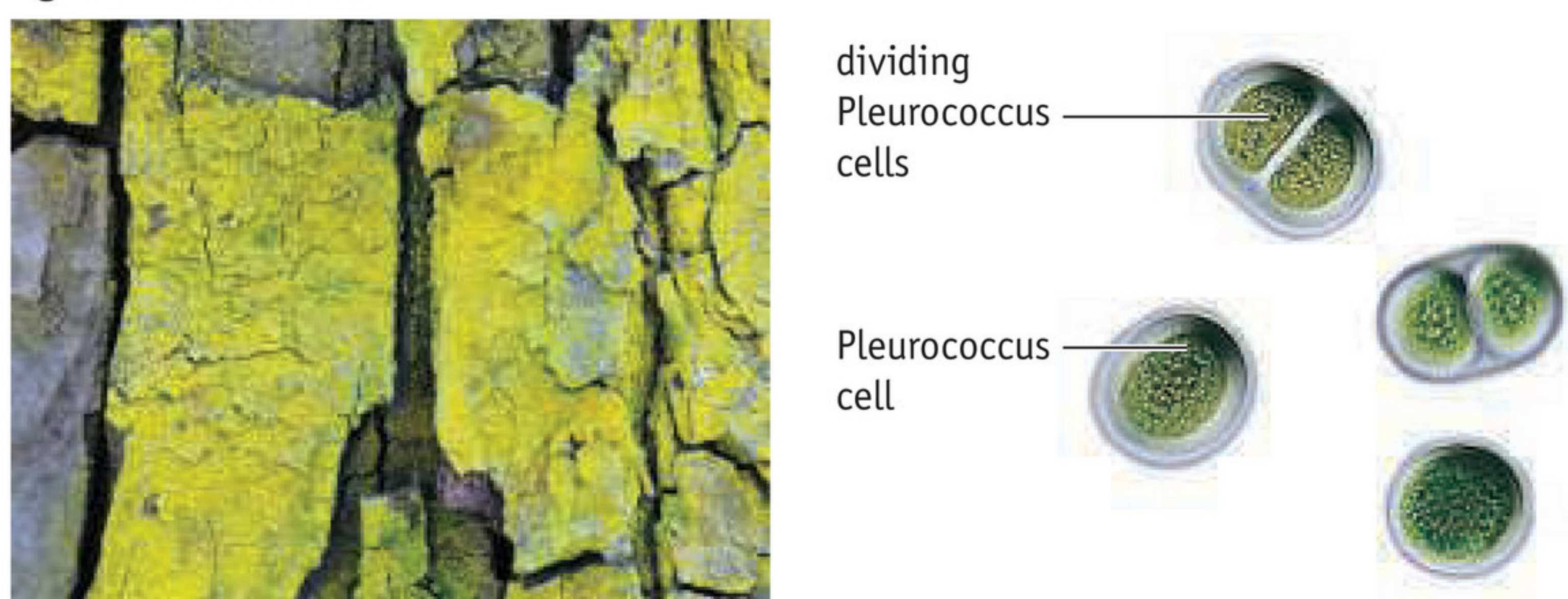
2 sporangia on the underside of a fern leaf

ALGAE

Most algae grow in water. That means they do not need roots and stems. They get their nutrients out of the water surrounding them. Algae also have no leaves and no flowers. The reproduction of algae is complex. Some algae can reproduce using spores. Many unicellular (single-celled) algae reproduce by cell division.

Green algae are single-celled or multicellular organisms with chloroplasts. Pleurococcus is an example of a single-celled green alga. They that can be found in large numbers on tree trunks and on walls. Together, these algae create the green deposits that you can find at these places (see figure 6.1). Pleurococci reproduce by division (see figure 6.2). An example of a multicellular green alga is sea lettuce. Sea lettuce grows in the sea in shallow water close to the coast (see figure 7). The plant is edible and is used in sushi, for example.

fig. 6 Pleurococcus.



1 Pleurococci make a green layer on trees

2 microscope photo of algae

fig. 7 Sea lettuce in the Waddenzee at low tide.

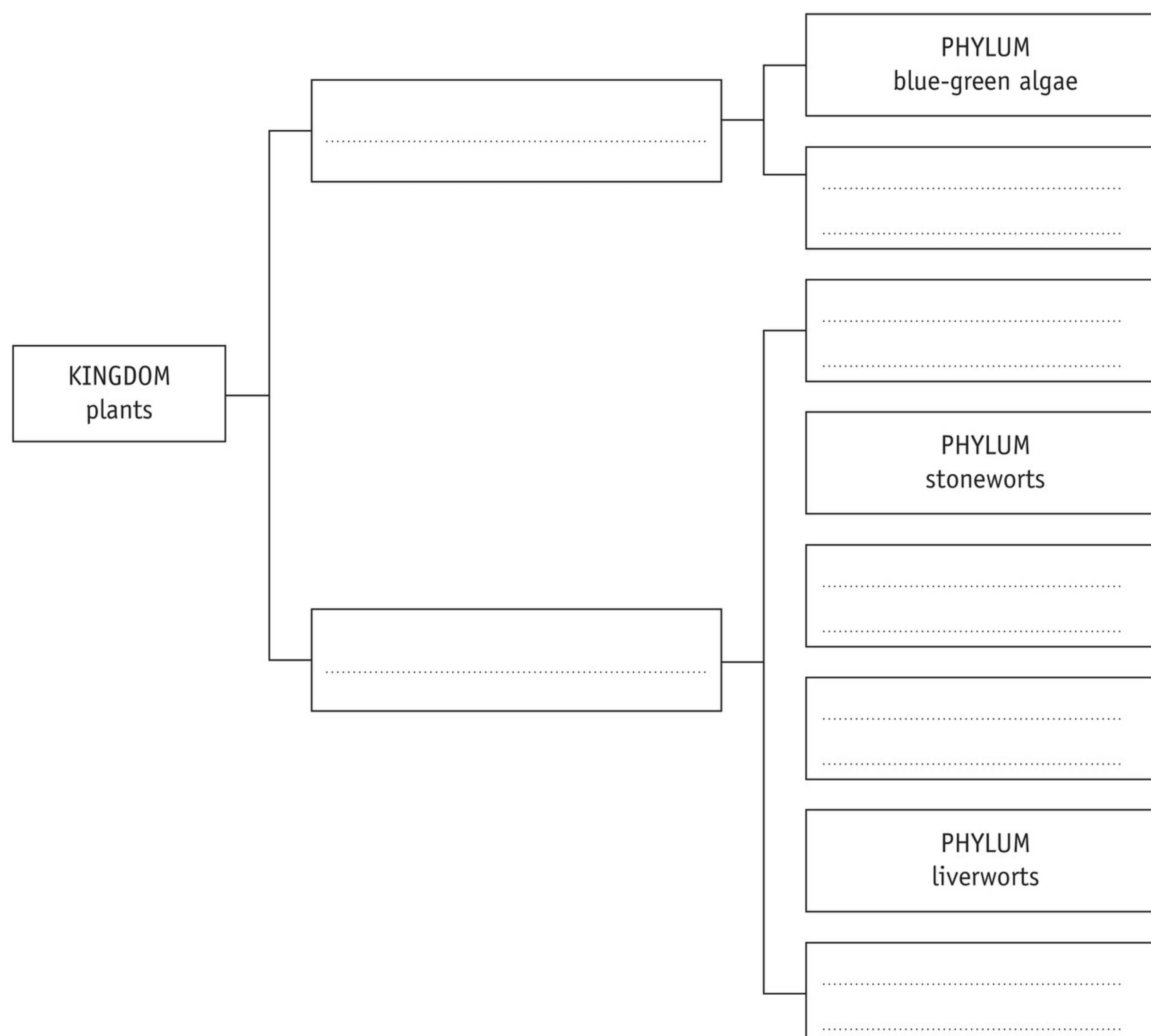


KNOWLEDGE

1

- a** List three features that biologists use for categorising plants.
- b** Figure 8 shows you a diagram with the classification of plants. Complete the rest of the table.

fig. 8



2

Most of the plants you know are vascular plants.

- a** What is the key feature of vascular plants?
- b** Which two plants are green algae?
- ☐ A bracken fern
 - ☐ B Pleurococcus
 - ☐ C oak
 - ☐ D dandelion
 - ☐ E common hair moss
 - ☐ F tomato plant
 - ☐ G sea lettuce
- c** Most green algae live in water. Explain why green algae do not need roots and stems.

3

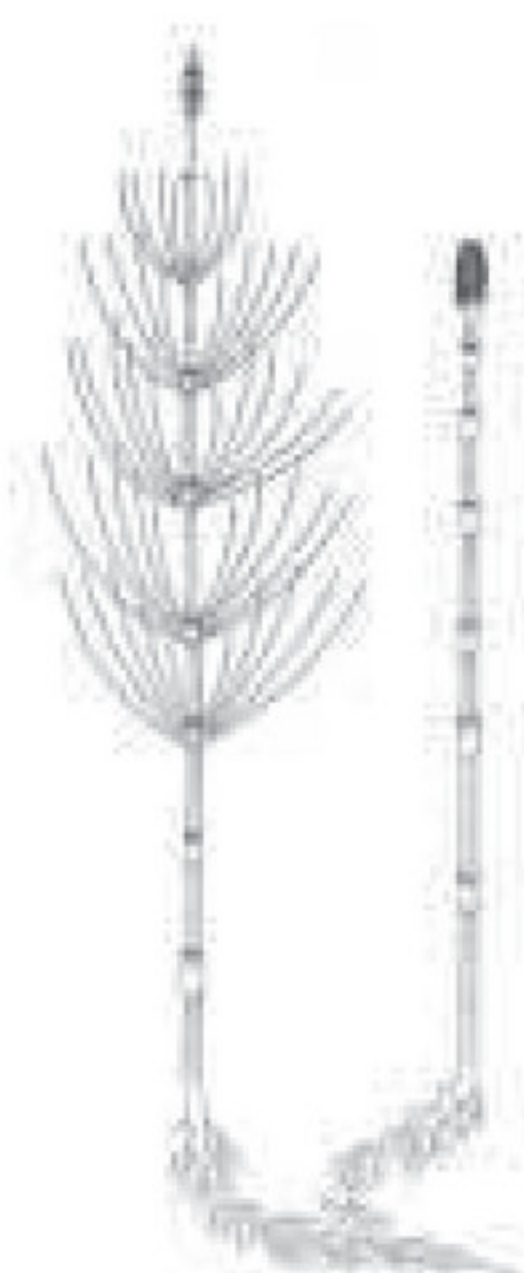
- a** How do vascular plants reproduce?
b Complete the sentence (using the same term twice).
 All seed plant are but not
 all are seed plants.
c How do palm trees reproduce? Explain your answer.

4

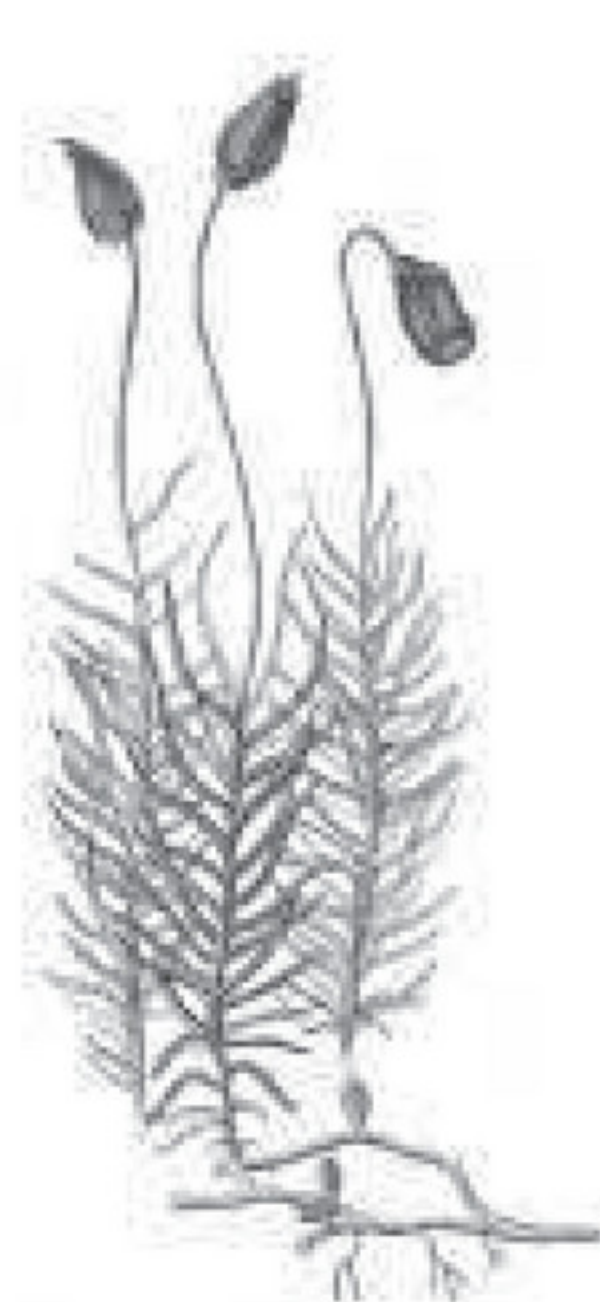


Figure 9 shows you three cryptogams (spore-bearing plants).
 For each of them, show the part where the spores are produced. Write down the name of that part next to it.

fig. 9 Spore-bearing plants.



1



2



3

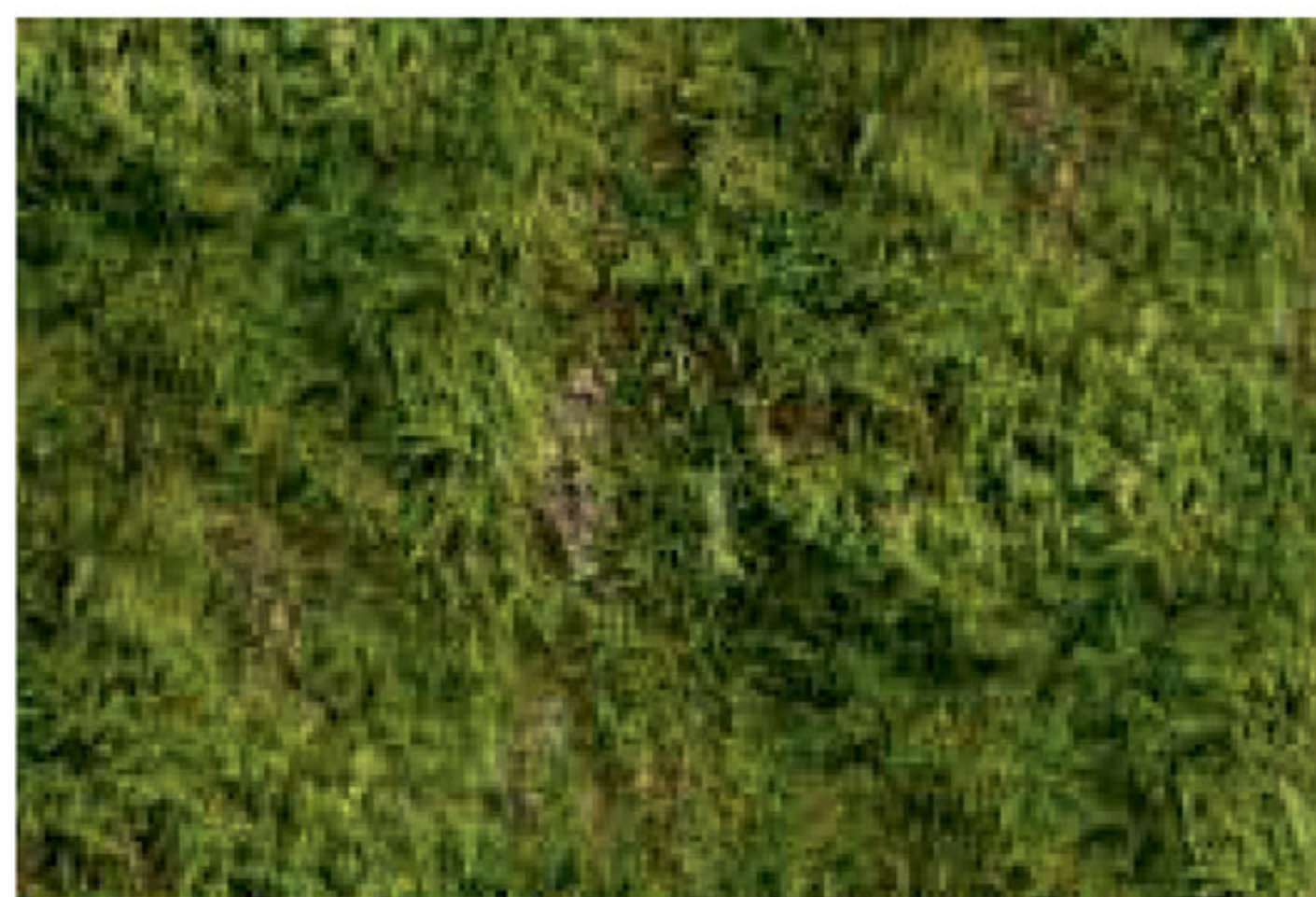
5

- a** Is it a seed plant or a spore-bearing plant?
- | | |
|--------------------|---|
| 1 bracken fern | <i>spore-bearing plant / seed plant</i> |
| 2 oak | <i>spore-bearing plant / seed plant</i> |
| 3 dandelion | <i>spore-bearing plant / seed plant</i> |
| 4 common hair moss | <i>spore-bearing plant / seed plant</i> |
| 5 tomato plant | <i>spore-bearing plant / seed plant</i> |
| 6 sea lettuce | <i>spore-bearing plant / seed plant</i> |
- b** Figure 10 shows you three photos of plants.
 Are they seed plants or spore-bearing plants?

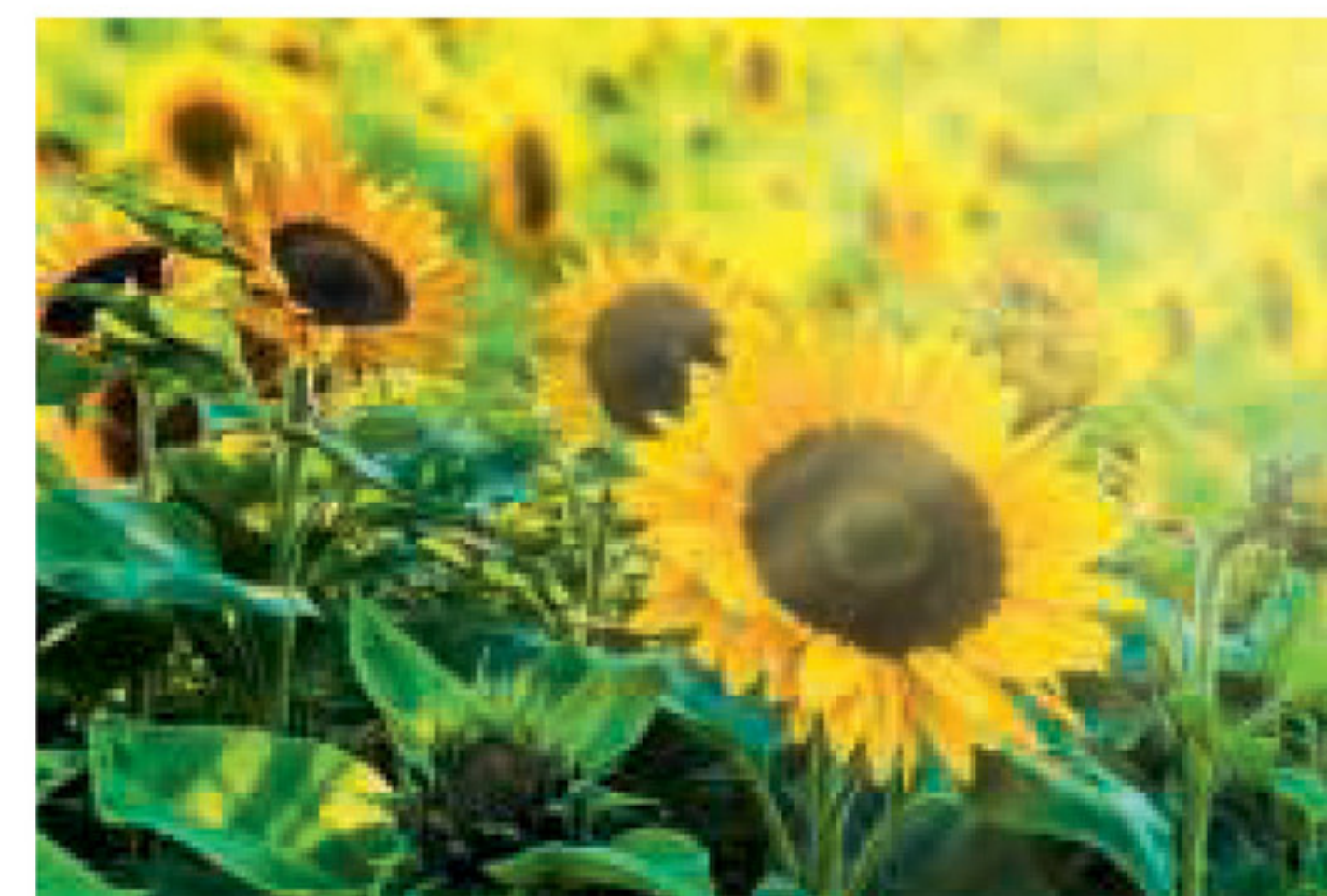
fig. 10



1 *spore-bearing plant / seed plant*



2 *spore-bearing plant / seed plant*



3 *spore-bearing plant / seed plant*

6



Summary

Make a summary of this Basics section. Complete the table. Answer *yes*, *no* or *sometimes* to questions 1 to 7.

Classification of plants	Method of reproduction		Phylum	
	seed plants	plants that make spores	vascular plants	green algae
1 Do they have roots?				
2 Do they have stems?				
3 Do they have leaves?				
4 Do they have flowers?				
5 Do they have seeds?				
6 Do they have spores?				
7 Are they multicellular?				
Examples				

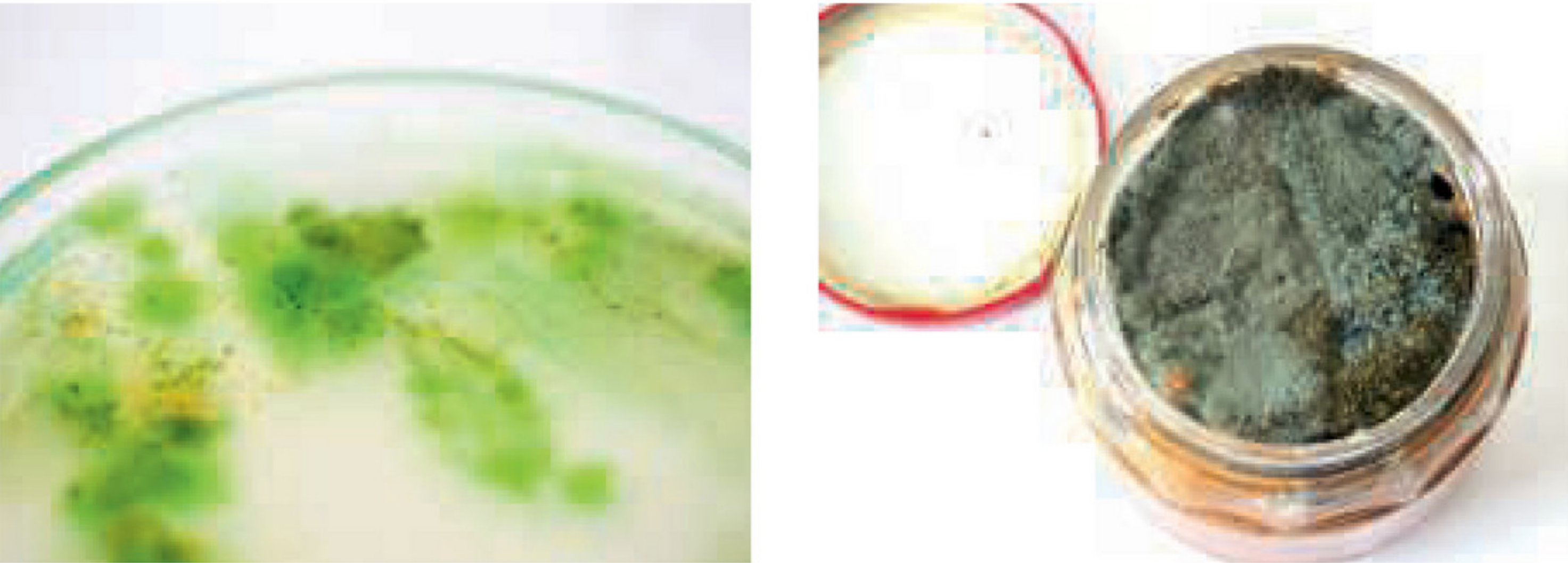
INSIGHT

7

Figure 11 shows you a Petri dish containing green algae and a pot of jam that has gone mouldy.

- a Why are green algae plants but green moulds are not?
- b Scientists have been discussing for years whether certain algae can really be called plants.
 - 1 Give one argument in favour of the statement that algae are plants.
 - 2 Give one argument in favour of the statement that algae are not plants.

fig. 11 Green algae and green mould.



8

At least 390,900 species of plants grow on the Earth, of which about 369,400 are flowering species. Biologists discover about two thousand new plant species every year.

- a How can you keep a clear overview of all the new species?
- b Which phylum do the 369,400 flowering plant species belong to?
- c How to the other roughly 21,500 plant species reproduce?
- d Survival training courses pay a lot of attention to recognising plants. Explain why this is important.

+ 9

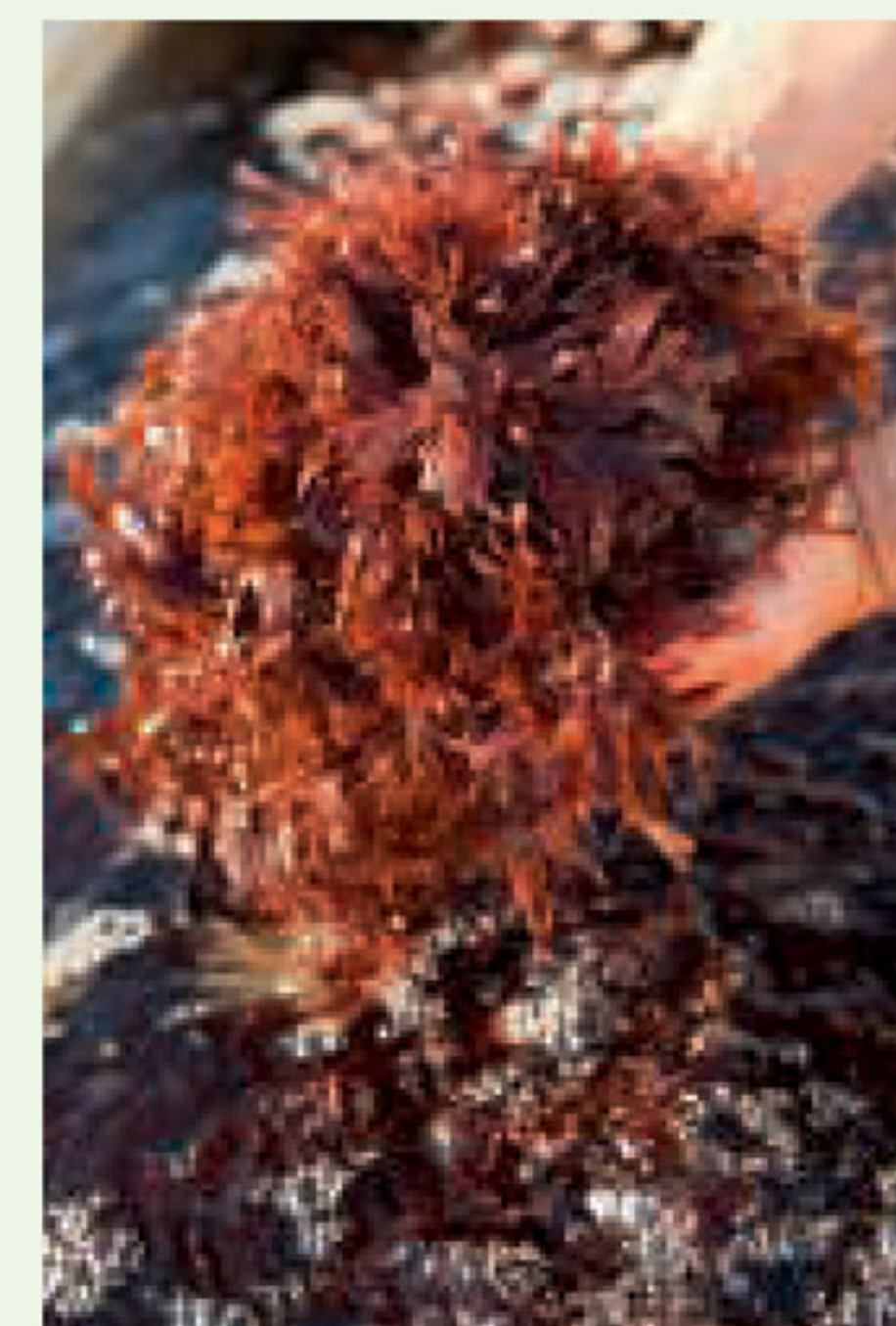
Read the text about “Red algae”.

One thing that is examined when classifying plants is the type of chloroplasts. Explain why this feature does not apply to all plants.

fig. 12

Red algae

Red algae are plants like dulse that are red rather than green (see photo). They can still photosynthesise, though. For photosynthesis, plants use plastids that can convert light into useful energy. One well-known example of such plastids are chloroplasts. Those contain a green pigment. Red algae do not have chloroplasts – they have rhodoplasts, a different kind of plastid that is also capable of photosynthesis. So these are not chromoplasts.



HOW IT FITS TOGETHER science

BIODIESEL FROM ALGAE

Algae need sunlight, water and a little bit of fertiliser to grow (nutrients). Sunlight is free; water and small quantities of fertiliser are cheap. So algae would seem very suitable for making fuels (biodiesel) from. Algae use photosynthesis to produce glucose. They use that glucose to make the substances that they are built of up, such as fats. Those fats can be used in turn to make biodiesel.

Diesel from petroleum is becoming more and more expensive and hard to find, so companies are looking for other ways to produce fuels. There is another reason why algae are suitable for making biofuels: they are single-celled. That means that algae can extract their nutrients directly from the water. They do not need roots for getting their food from the soil. Other plants such as maize are also used for making biofuels. But that needs agricultural land, which is then no longer available for growing food. That is not very helpful, given that the world population is increasing.

fig. 13 Research into algae for biodiesel.



10

Read the text ‘Biodiesel from algae’.

- What cell features do algae have?
- What makes single-celled algae suitable for producing biodiesel whereas bacteria (also unicellular) are not?
- Why do single-celled algae seem to be a more sustainable source of biofuels than multicellular maize plants?
- Explain why all fuels ultimately come from photosynthesis.

 Go to the *Flash cards* and the *Test yourself* section.

5 Fungi

LEARNING OBJECTIVES

- 3.5.11 You can list features of fungi.

3.5.12 You can explain that fungi can be both useful and harmful and you can give examples of both.
- Learning how to do research 3

► Practical activities 4, 5 and 6

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES				
	3.5.11	3.5.12	3.1.2*	3.2.5*	3.4.9*
Remembering	3bcd	4ab, 5			
Understanding	1, 2, 3a, 6	4c, 6	1		
Using	10ab	8ab			10a
Analysing	7, 8c, 9, 10c	8c, 9a, 10d	9c	9b	9c, 10c

* You can find this learning objective in another unit.

About 100,000 species of fungi have now been described but there may be as many as 1.5 million species. Fungi can be harmful to people but they are also often very useful.

STRUCTURE

Fungal cells have a nucleus and a cell wall but no chloroplasts. They are therefore not able to photosynthesise. Fungi can be single-celled or multicellular. **Yeasts** are unicellular fungi (see figure 1). Multicellular moulds generally form a mycelium of long, thin filaments known as **hyphae**. You can find these on a mouldy piece of bread, for instance (see figure 2). You can see the threads clearly under a microscope.

fig. 1 Yeast.

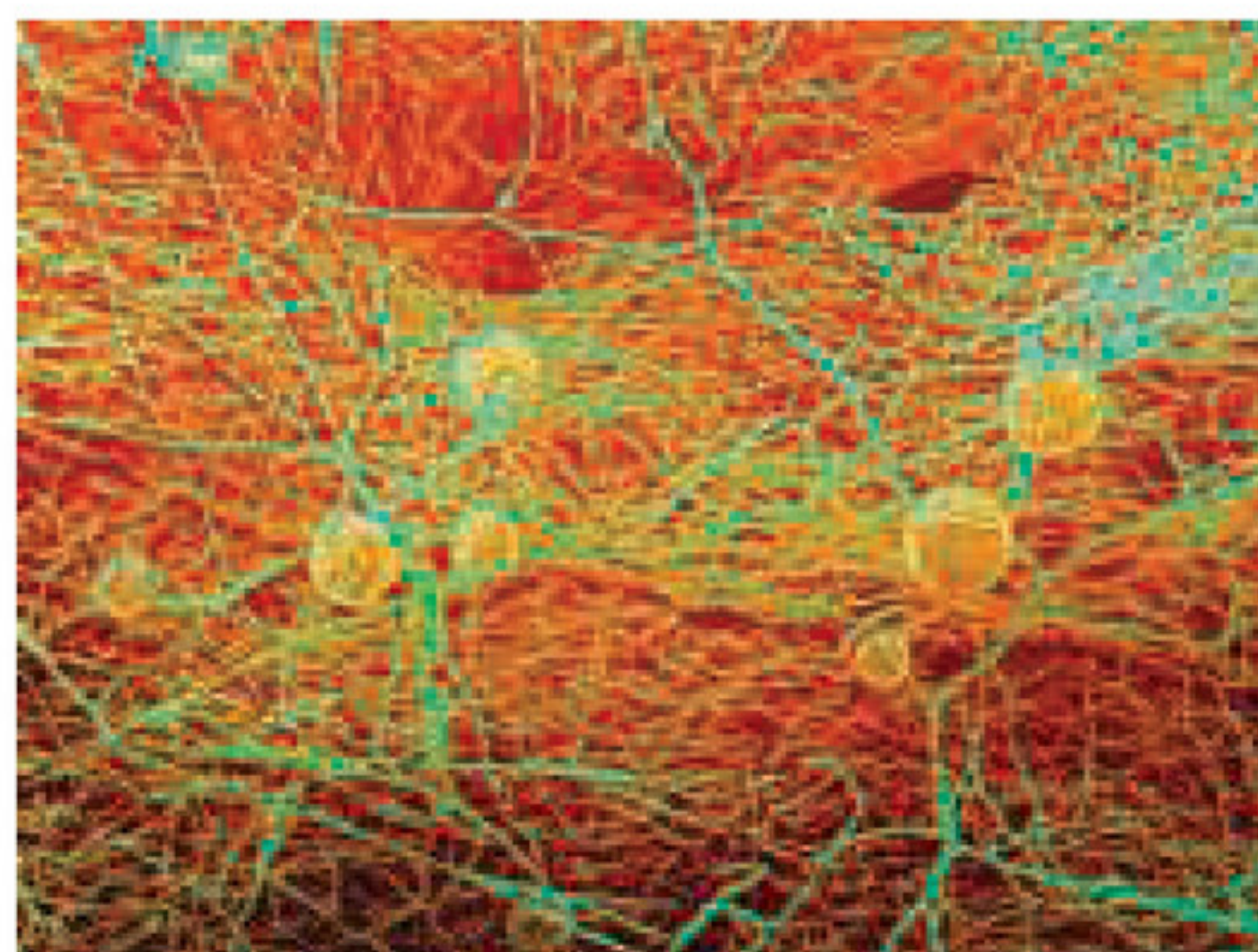


- 1 Bakers' yeast consists of yeast cells.

2 An electron microscope photo of yeast cells (3200× magnification)

fig. 2 Hyphae (fungal filaments).

1 fungal filaments on a mouldy piece of bread



2 microscope photo (600× magnification)

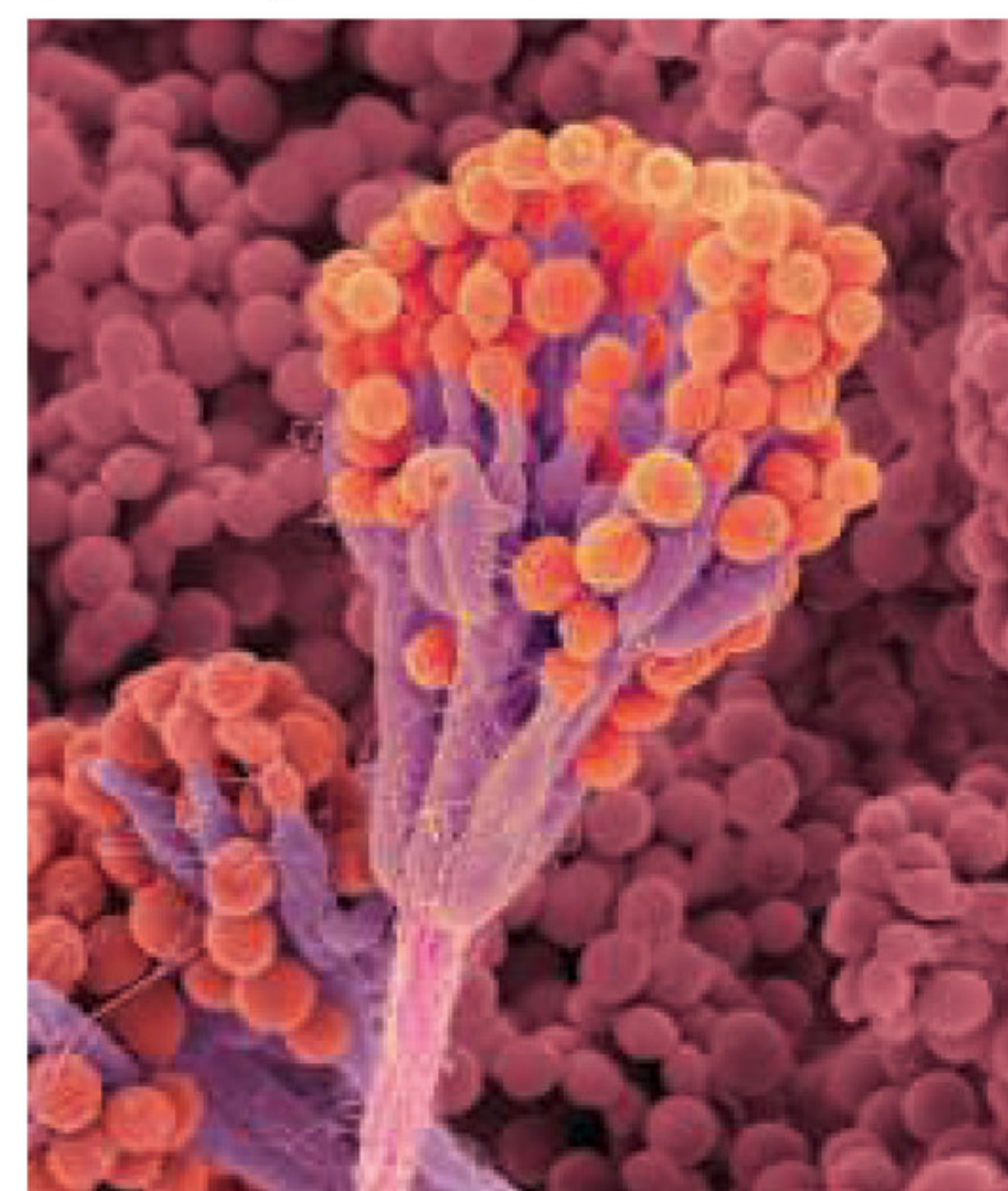
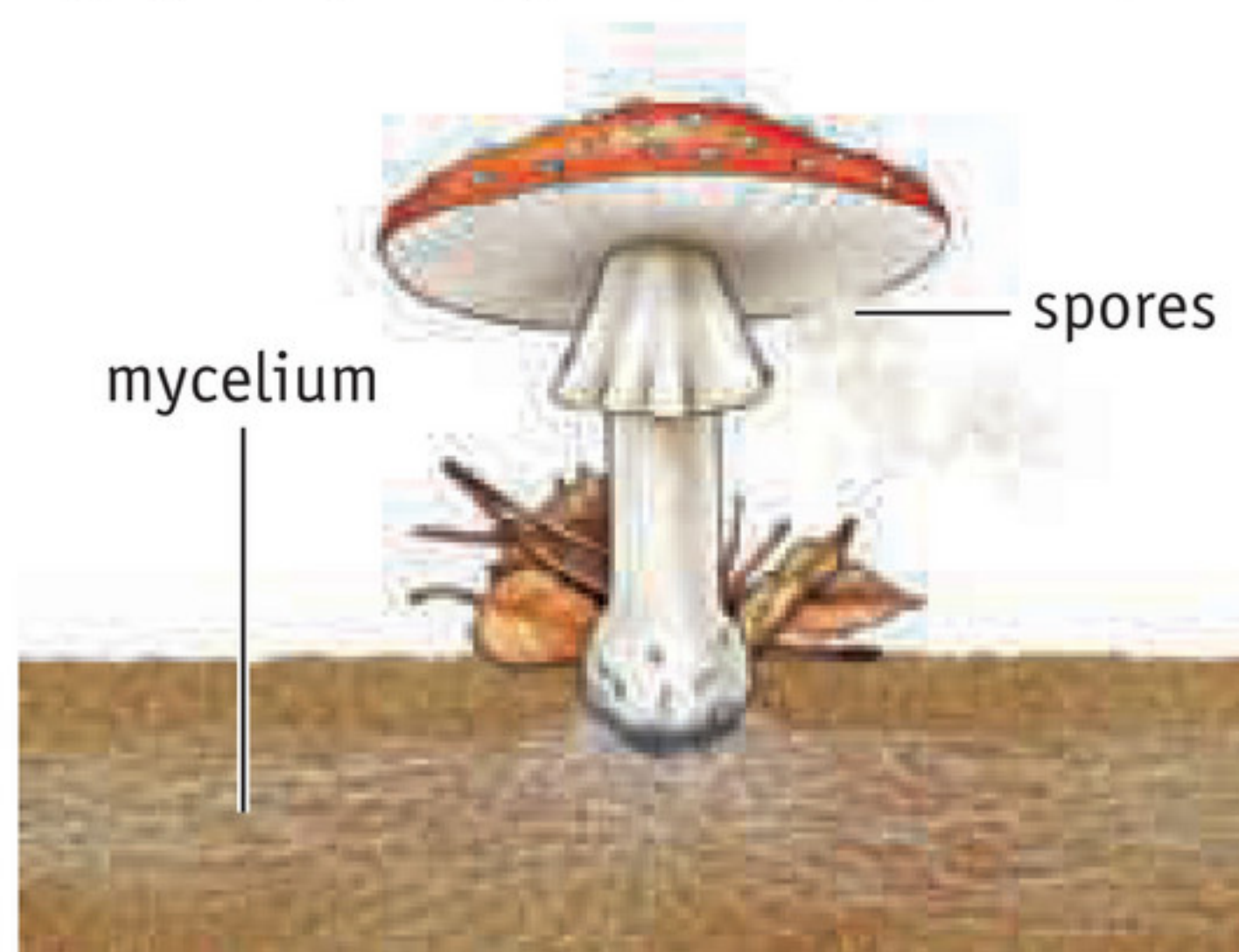
REPRODUCTION

Yeasts reproduce by cell division. Yeast cells that are dividing produce a **bud**. This bud becomes a new yeast cell (see figure 1.2).

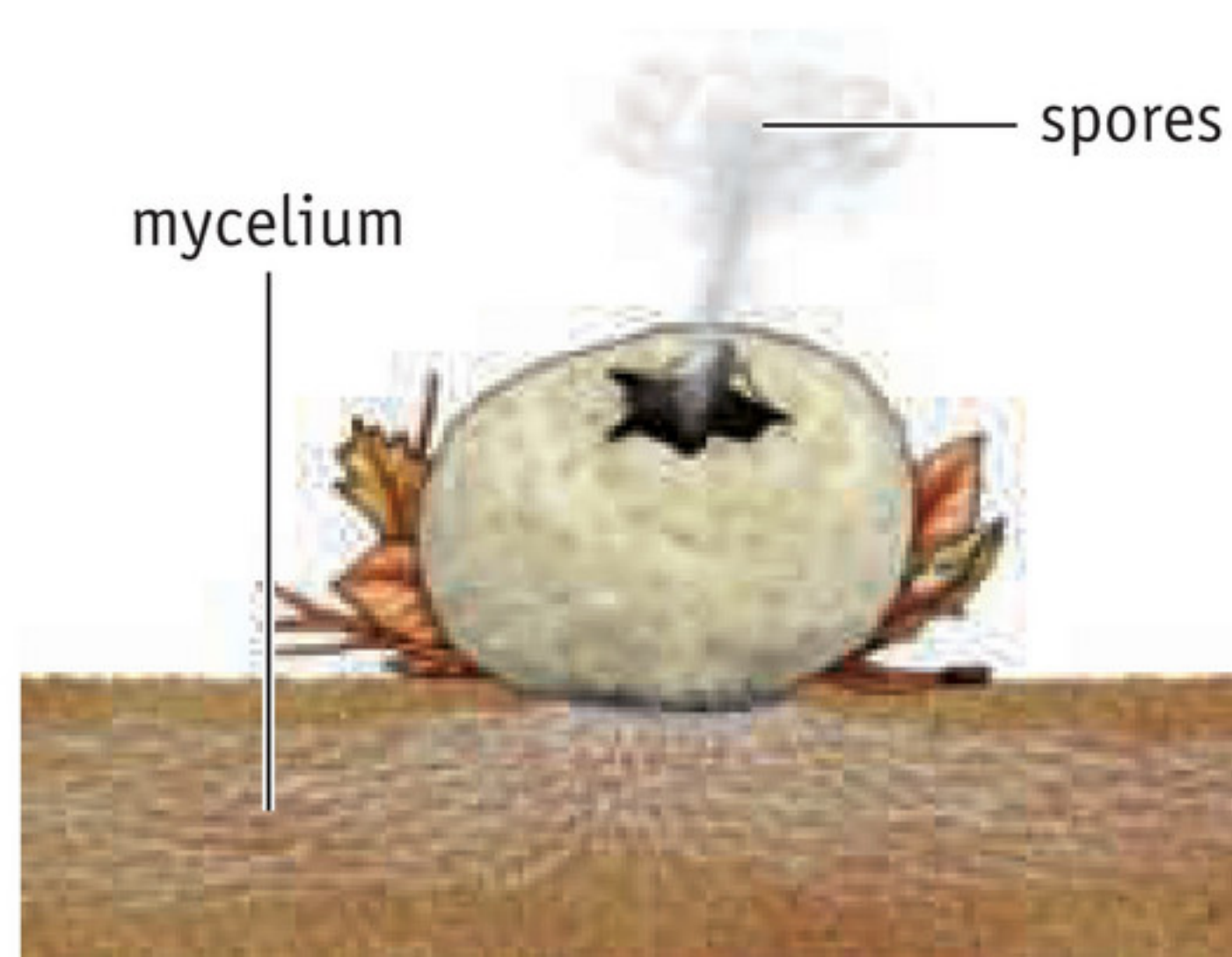
Multicellular fungi generally reproduce through spores (cells that can grow into a new fungus). In many types of fungi, the spores appear at the ends of fungal filaments that grow upwards. The penicillium mould is one example (see figure 3).

There are other types of fungi in which the spores are made in special organs: **toadstools**. This is for instance the case in fly agaric and puffballs (see figure 4). Toadstools are involved in the reproduction of fungi.

The toadstools of some types of fungus are edible, for instance the toadstools of fungi such as mushrooms.

fig. 3 Penicillium mould (600× magnification).**fig. 4** Fungi that produce toadstools.

1 fly agaric



2 puffball

USEFUL AND HARMFUL

Most types of fungus feed on the dead residues of organisms. An important function of fungi in nature is that they clear up the remains of dead organisms (see figure 5). Our food also consists of the dead remains of organisms, such as fruit and vegetables. Fungi can live perfectly well on that too (see figure 6). This is how fungi can spoil food.

fig. 5 Fungi clear up the remains of plants and animals...**fig. 6** ...in the kitchen too!

Some species of fungi can cause diseases in plants, animals or humans. This is called an **infection**. In humans, athlete's foot is caused by a mould, for instance. In this condition, the skin between the toes becomes inflamed. Fungal infections can be tackled using medicines.

BIOTECHNOLOGY

Biotechnology is a collective term for techniques in which people use living organisms to produce goods. Many biotechnology techniques have been used for centuries. People use moulds and yeasts to produce foods such as bread, beer, wine and cheese.

Bakers add yeast to the dough when they are preparing bread. That makes the dough rise and makes the bread light and airy (see figure 7). Yeasts are also used in making beer and wine (see figure 8). The yeast cells produce alcohol. Blue cheese is made using special moulds.

Moulds are also used for making medicines. The penicillium mould (see figure 3) is used for making the **antibiotic** called penicillin. Antibiotics are medicines that kill bacteria.

fig. 7 Bread dough.

1 before the yeast has had any effect...



2 ...and after.

fig. 8 Fungi are used in preparing these foods.

KNOWLEDGE

1

There are all sorts of microorganisms such as bacteria and fungi on the scalp of a human. One of those fungi, a yeast, can cause dandruff. When someone has dandruff, the skin cells are shed more quickly than normal. The cells have not dried out entirely by then, so they stick together. The lumps of cells can be seen as white flakes in the hair and on the clothing.

- a What cell features does the fungus that causes dandruff have?
- b Is the fungus that causes dandruff unicellular or multicellular? Explain your answer.

2

- a Can a fungus make its own food? Explain your answer.
- b Is a puffball (see figure 4.2) part of a single-celled fungus or a multicellular one? Explain your answer.

3

- a Fill in the missing word.

Fungi are everywhere. They produce that spread through the air and can end up almost everywhere in the world. As you read this, you are probably sitting on some and there are probably some on you. When you inhale, you take in hundreds of in every breath.

- b How do yeasts generally reproduce?
- c Where are the spores of the penicillium mould produced (see figure 3)?
- d Where are the spores of fly agaric produced (see figure 4.1)?

4

- a What is the name for a disease that is caused by a fungus?
- b Give an example of a condition that is caused by a fungus.
- c Penicillium moulds are used in tackling diseases. Explain why.

5

Yeast is used in bread-making.

- a Why do bakers add yeast to the bread?
- b Yeasts are also used in brewing beer and in wine-making. What is the purpose of the yeast here?
- c The techniques for using fungi in producing food (such as yeasts for bakers and for brewing beer and making wine) have been used for centuries. What is the collective term for these techniques?

6

Summary

Make a summary of this Basics section. Do that by answering the questions.

- What are the features of fungal cells?
- Can fungi photosynthesise?
- Describe the structures and methods used by unicellular and multicellular fungi for reproduction.
- Explain how fungi can be both useful and harmful.

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INSIGHT

7

- Porcini are edible toadstools (see figure 9).
- a** Sketch the lifecycle of the porcini mushroom. Add the names to the parts.

- b** Explain why a wet summer followed by a windy autumn is good for the reproduction of toadstools.

fig. 9 Porcini.



8

Aspergillosis is an illness that is caused by a fungus of the *Aspergillus* genus. In the body, the fungus triggers an allergic reaction and lung problems.

- a** Judith says, “Aspergillosis can be cured by giving you the antibacterium penicillin, which is made from fly agaric.”
There are three things Judith has got wrong. Explain.
- b** The antibiotic penicillin stops bacteria from making cell walls.
Why is penicillin not harmful to humans and other animals but is harmful to bacteria?
- c** Fungi have cell walls just like bacteria do but they are not sensitive to penicillin because their cell walls have a different structure. In fact, they grow better if you are taking penicillin.
Give an explanation for this.

+ 9

Read the text on ‘The Humungous Fungus’.

Fungi mostly live underground.

- a** What might give you the idea, as a researcher, that a fungus was the reason why large numbers of trees were dying off?
- b** To discover how large the fungus was, the researchers collected pieces of mycelium at various places in the woodland.
How could they then show that all those pieces belonged to a single organism (and not for instance to two different organisms of the same species)?
- c** The crown of a tree consists of twigs and leaves.
Explain step by step how the fungal infection can make the tree’s crown grow thinner and then kill the tree.

fig. 10

The Humungous Fungus

The network of dark brown fungal threads of *Armillaria ostoyae* or “root rot fungus” covers an area of 880 hectares. This makes it the world’s biggest organism. Researchers discovered the Humungous Fungus when they heard about a lot of tree deaths caused by root rot in the Malheur Forest in the American state of Oregon. The root rot fungus grows with its mycelium threads in living conifer trees from which it extracts water and nutrients. The trees’ roots are affected and they then get a thin and transparent crown before they finally die. The fungus then continues to live on the dead, rotting material.

After: ‘The world’s biggest toadstool covers 880 hectares’, NRC, 7 August 2000.



Toadstools of the root rot fungus.

HOW IT FITS TOGETHER the living world

DUTCH ELM DISEASE

Dutch elm disease is a major threat to elms, a species of tree that occurred a great deal in the Netherlands until the twentieth century but has now become rare because of this disease. Dutch elm disease is caused by a fungus that grows in the vessels of elms, blocking them. This makes the leaves shrivel and the tree then dies. The fungus is spread by the European elm bark beetle, which lays its eggs under the bark of a dead or weakened tree. The larvae that come out of the eggs then each burrow their own way in, crosswise to the main vessels (see figure 11.1), where they make a small chamber to pupate. The beetles fly out in the summer and eat into young elm shoots.

fig. 11 Elms affected by the European elm bark beetle.



1 holes burrowed by elm bark beetle larvae



2 A sticky strip is put around the elm in an attempt to trap the beetles.

10

Read the text about 'Dutch elm disease'.

- a** How does the fungus in the elm get its food?
- b** Explain how the elm bark beetle transfers the fungus to another elm.
- c** The elm bark beetle lays its eggs in a dead or weakened elm, not in a healthy one. The weakened elm can then be infected by the fungus. A healthy elm that is growing close to an infected one then often gets infected by the fungus too.
Explain how the fungus can spread to a healthy elm without the 'help' of the elm bark beetle.
- d** Is the fungus that attacks the elms useful, harmful or both? Explain your answer.

 Go to the *Flash cards* and the *Test yourself* section.

6

Bacteria

LEARNING OBJECTIVES

- 3.6.13 You can list features of bacteria.

3.6.14 You can explain that bacteria can be both useful and harmful and you can give examples of both.
- Learning how to do research 4

► Practical activity 7

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	3.6.13	3.6.14	3.1.3*	3.5.12*
Remembering	1abc	2abcd		
Understanding	1d, 3	2e, 3		
Using	7abc, 8	5, 6, 7ab	7c	
Analysing	4, 7de	7d, 9		9

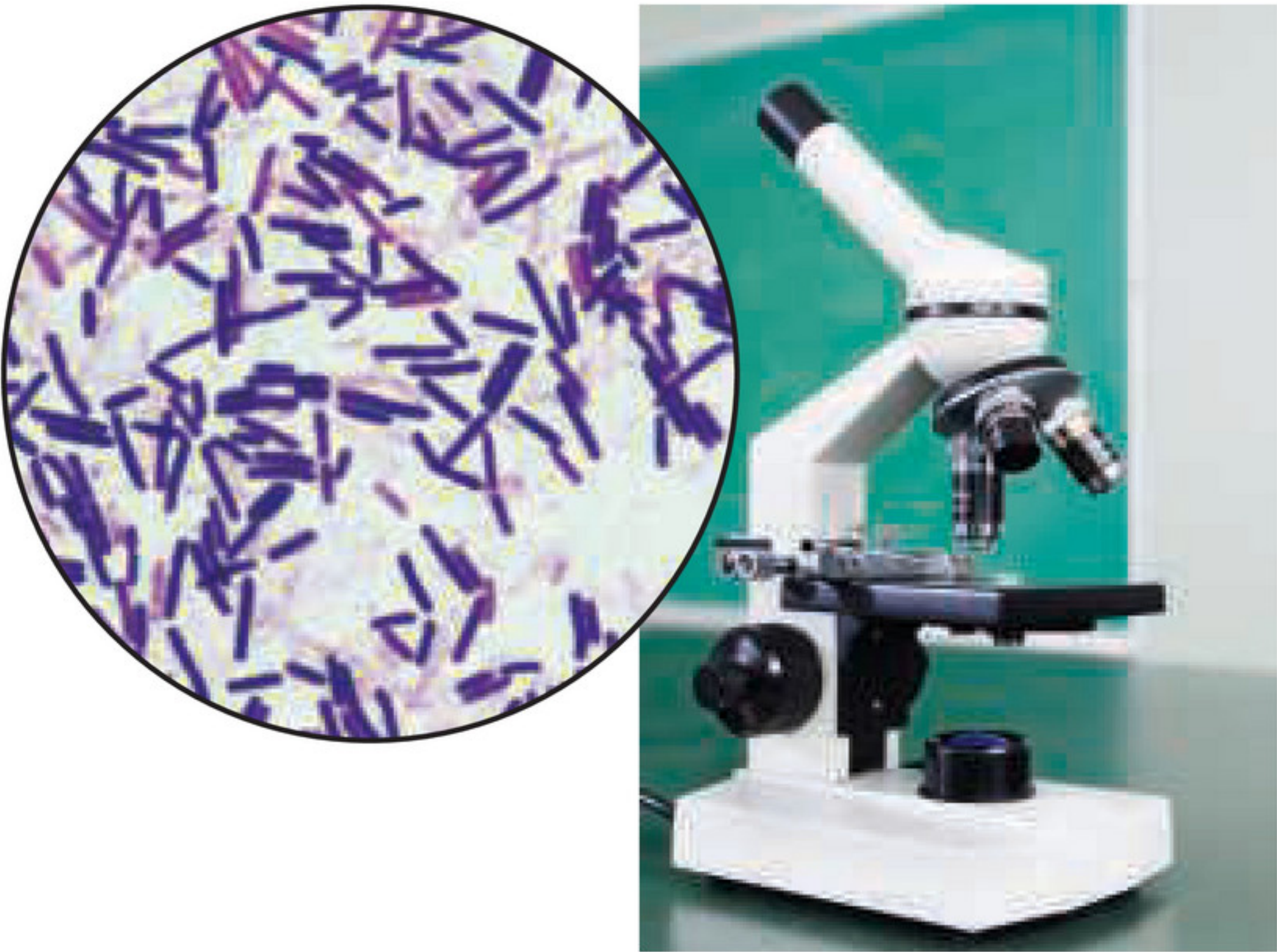
* You can find this learning objective in another unit.

You can’t see them without a microscope but they’re everywhere: bacteria. Your body is full of them too. Just in your mouth, there are about 25× as many bacteria as there are people on the Earth.

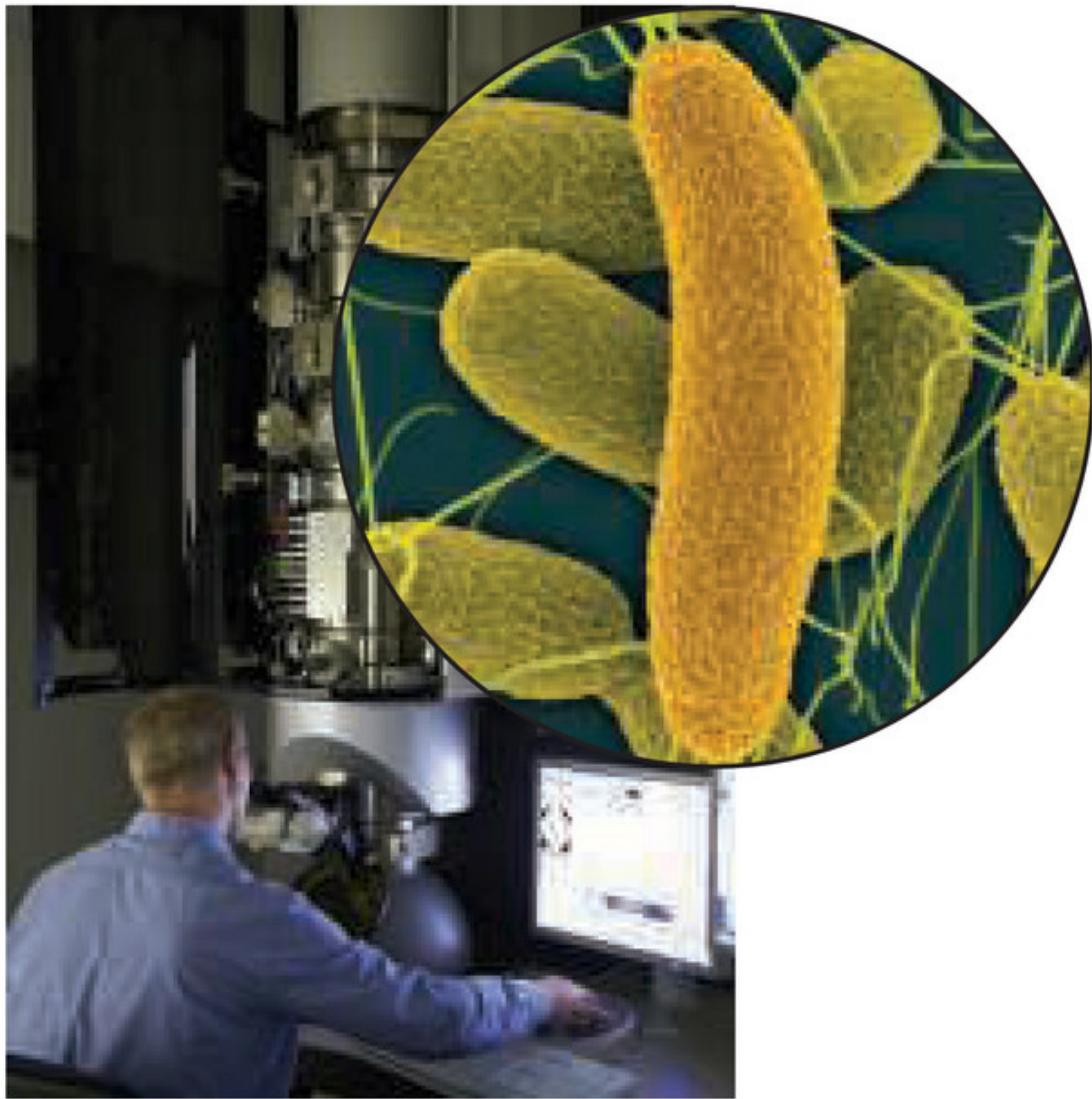
STRUCTURE

Bacteria are prokaryotes: single-celled organism without a nucleus. Prokaryotes are very small - so small that you can only see them as dots or lines, even with a light microscope (see figure 1.1). To study bacteria properly, you need an electron microscope (see figure 1.2). That type of microscope can magnify things hundreds of thousands of times.

fig. 1 This is what bacteria look like.



1 under a light microscope

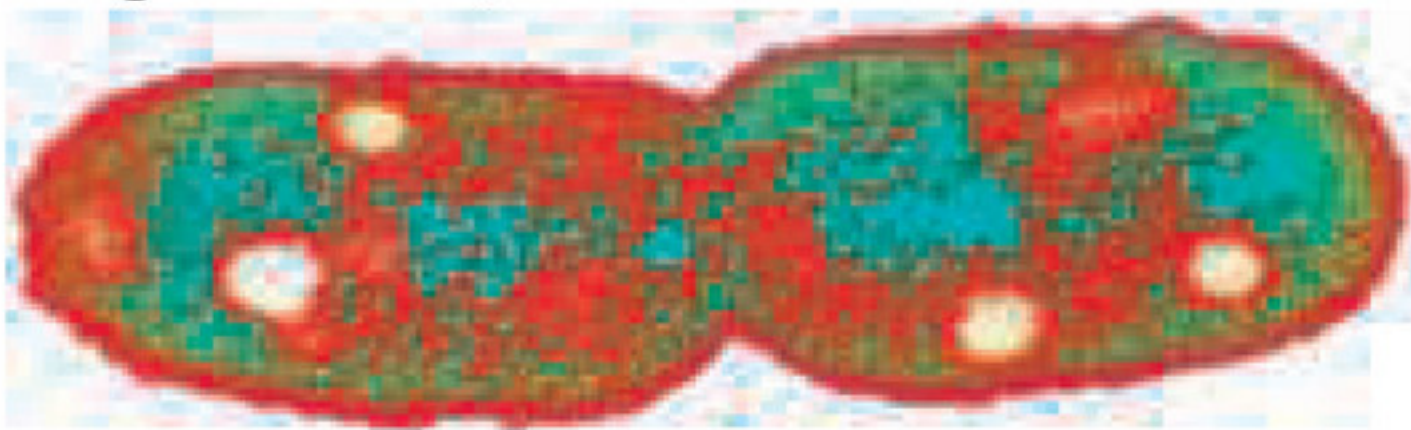


2 under an electron microscope

REPRODUCTION

Bacteria reproduce by cell division. This produces two smaller cells (see figure 2). These then grow until they are just as big as the original cell. Bacteria can reproduce very quickly. Under favourable conditions, some bacteria can divide every twenty minutes.

fig. 2 A bacterium dividing (electron microscope photo at 44,000× magnification).



USEFUL AND HARMFUL

Bacteria are everywhere. Billions of them live on and in your body. Your intestines in particular are full of them. These bacteria help your body digest your food so that your intestines can absorb the nutrients. A layer of bacteria on your skin protects you against pathogens.

Most types of bacteria feed on the dead residues of organisms. In the soil, bacteria clear away the remains of dead organisms. This releases nutrients that the plants can take up. Our food is often made up of the remains of organisms, such as fruit, vegetables and meat. Bacteria can live on this perfectly well. This is why food can go bad.

As well as lots of useful species of bacteria, there are also harmful ones that can get inside your body and cause diseases. Examples of infectious bacterial diseases are cholera, pneumonia, ear infections, tuberculosis and bladder infections. Infectious bacterial diseases can be tackled with antibiotics such as penicillin.

BIOTECHNOLOGY

Bacteria are used in making foods, just like fungi are. Examples include yoghurt and sauerkraut (see figure 3). Yoghurt is made from milk that bacteria have been added to. The bacteria convert part of the milk into lactic acid. That's what gives yoghurt its sour taste. Sauerkraut is made from white cabbage. The bacteria soften the hard cabbage and make it a little bit acidic.

fig. 3 Yoghurt and sauerkraut.



KNOWLEDGE

1

- a** What are the features of bacterial cells?
- b** How does a bacterium reproduce?
- c** How quickly can a bacterium divide under ideal conditions?
- d** Figure 4 shows you two photographs of bacteria.
 Photo 1 was made using *an electron microscope / a light microscope*.
 Photo 2 was made using *an electron microscope / a light microscope*.

fig. 4 Bacteria from the intestine dividing.

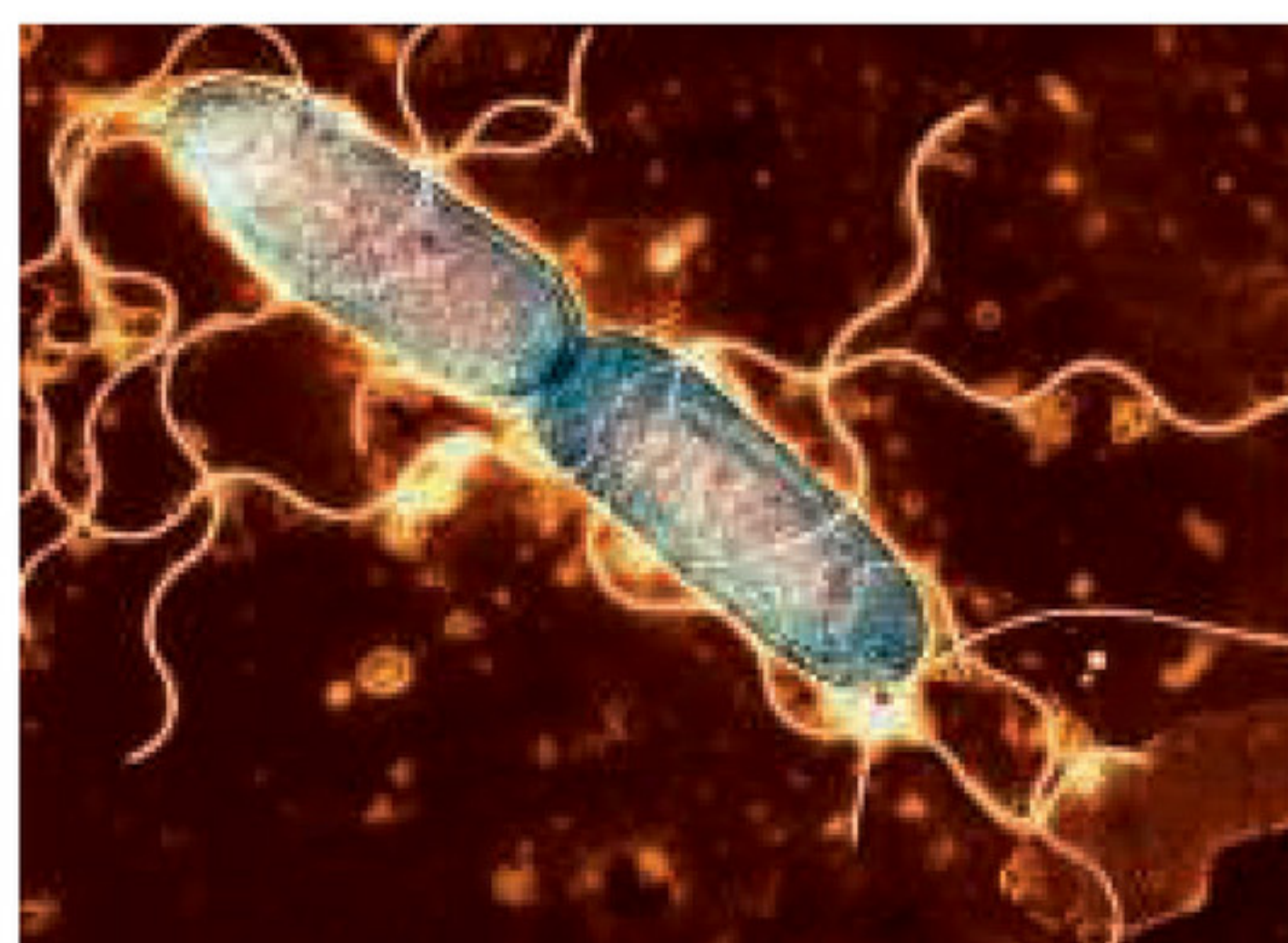


photo 1

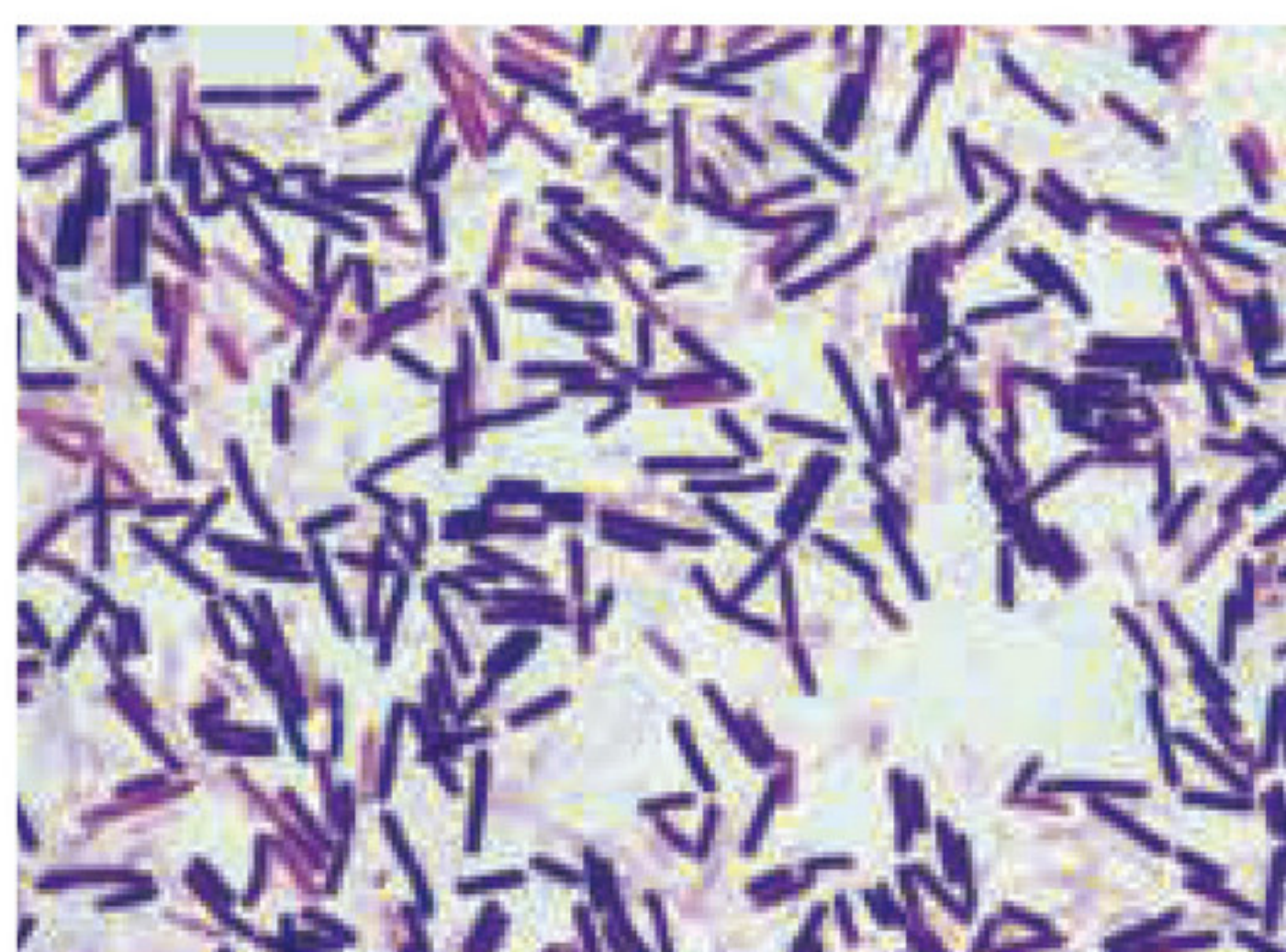


photo 2

2

- Billions of bacteria live on and in your body.
- a** What is the function of the bacteria in your gut?
 - b** What is the function of the layer of bacteria on your skin?
 - c** In the soil, bacteria clear away the remains of dead organisms.
Explain why this is good for plants.
 - d** There are often lots of bacteria on our food.
Explain why there are lots of bacteria on our food.
 - e** There can be lots of bacteria on meat and fish.
Explain why that is harmful to humans.

3



- Summary**
- Make a summary of this Basics section.
- Write down the domain and the cell features of bacteria.
 - Give a brief description of reproduction in bacteria.
 - Give examples of useful and harmful bacteria.
 - Explain how infectious bacterial diseases can be tackled.

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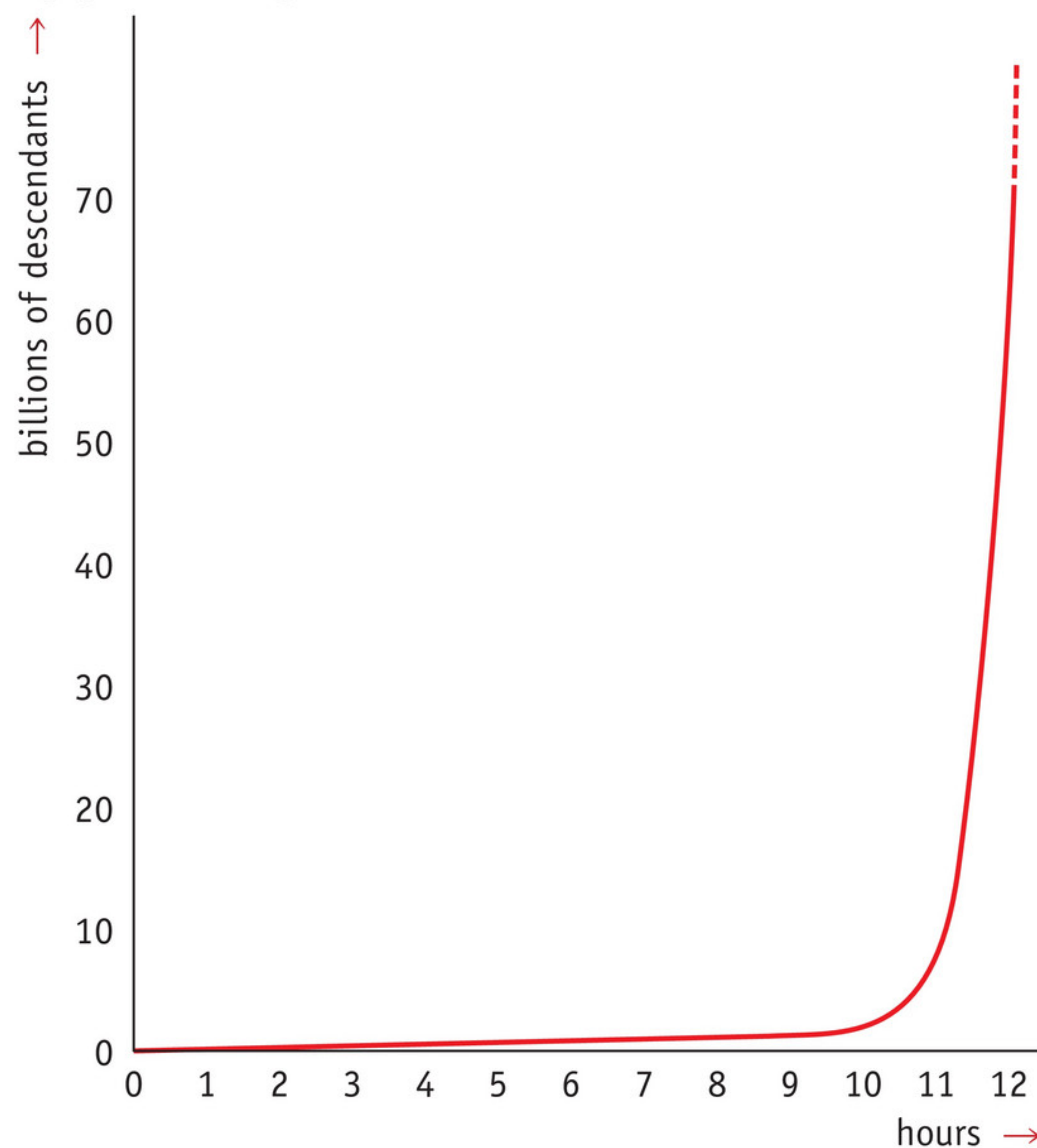
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INSIGHT

4

If the conditions are just right, a single bacterium can have as many as 68 billion descendants after just twelve hours (see figure 5). After just a few days, the whole planet would be covered in those bacteria.

Explain why a bacterium can never reproduce as quickly in reality as it does in this graph.

fig. 5 Bacterial growth.**5**

Food goes bad more quickly in hot weather. That is why the Dutch Food and Consumer Product Safety Authority recommends hygiene, proper cooling and thorough cooking. Explain how each of those recommendations helps tackle food spoilage.

6

The human body is a perfect spot for bacteria. It is warm and moist and full of food. There is also a protective layer of good bacteria on your skin.

- a** Explain how a layer of bacteria on your skin protects you against pathogens.
- b** Some kinds of soap contain special compounds that kill bacteria on the skin. If you use these kinds of soap a lot, you may become more likely to pick up infections. Explain why.

+ 7

Read the text about “Bifidobacteria”.

- a** Which bacteria can withstand an acidic environment better: bifidobacteria or the harmful bacteria in the large intestine? Explain your answer.
- b** Can bifidobacteria also have a positive effect on your health when they are on your skin? Explain your answer.
- c** Do all bifidobacteria belong to the same genus?
- d** A bacterial strain is a group of bacteria that has been cultured from a single bacterium.
In bacteria, what is the difference between a bacterial species and a bacterial strain?
- e** Some bifidobacteria have a favourable effect on how the intestines work but others don't. So it is important to distinguish properly between the species and strains. That used to be a time-consuming task. The bifidobacteria were cultured in a laboratory and then all kinds of biochemical tests were needed to show what properties the bacterial strains had. Nowadays, scientists use DNA technology.
Can you use DNA technology to distinguish between the various bacterial strains of a single species/ Explain your answer.

fig. 6

Bifidobacteria

Bifidobacteria occur naturally in your large intestine. These bacteria do not grow well – or not at all – when oxygen is present, but the conditions in your gut suit them very well. They produce acetic acid and lactic acid there, which can make harmful bacteria grow less well. That is why it is often said that this family of bacteria are good for the health of your intestines. That's why they are added as probiotics to foods such as the yoghurt drink in the photograph. Probiotics are bacteria that have a positive effect on how your intestines function. The bifidobacteria family consists of several species that can then be classified further into bacterial strains. Some bacterial strains have a positive effect on health and others don't.

Source: 'Bifidobacteriën, gezondheidsbevorderende micro-organismen of toch niet?', NIBI via Nemo Kennislink, Koen Venema, 2003.



probiotics in a yoghurt drink

HOW IT FITS TOGETHER biology in professional life**MEDICAL MICROBIOLOGICAL ANALYST**

Nicola works as a medical microbiological analyst at a hospital.

“In our laboratory, I look to see whether there are lots of pathogenic bacteria in urine samples, for instance. Tests like that are done when a doctor suspects that a patient has a bladder inflammation. You cannot see individual bacteria with the naked eye. As they divide, though, they create bacterial colonies that you can see. I use an inoculating needle to put a tiny bit of urine on a culture medium in a Petri dish, and then leave it in an incubator at 37 °C. If there are any bacteria in the urine, they will multiply rapidly. After about 24 to 48 hours in the incubator, each bacterium on the culture medium will have grown into a bacterial colony. Bacterial colonies are visible to the naked eye. Then I investigate to see what bacterium has caused the infection.”

fig. 7 Nicola at work.



8

Read the text about a “Medical microbiological analyst”.

- a How can a medical microbiological analyst make the pathogenic bacteria in a urine sample visible to the naked eye?
- b Medical microbiological analysts refer to ‘bacterial growth’. Explain what they mean by that.
- c Explain why bacteria are cultured at a temperature of 37 °C.

9

There are various types of antibiotics: broad-spectrum and narrow-spectrum. A broad-spectrum antibiotic works against lots of bacterial species at the same time. A narrow-spectrum one only works against a single bacterial species.

- a What is the drawback of a broad-spectrum antibiotic?
- b Explain why it is important that Nicola investigates what species of bacterium has caused the infection.

 Go to the *Flash cards* and the *Test yourself* section.

How it fits together

WATER BEARS UNDER YOUR BEACH TOWEL

Lots of people value their privacy, even when they're on the beach. They generally don't like putting their beach towel down too close to someone they don't know. But because they don't realise it, they don't mind lying on top of all kinds of creatures.

It is estimated that there are about eight million small organisms under a single beach towel. That's almost as many as the number of cars in the Netherlands. But it's OK – there's still a beach towel between you and them. One of those organisms is the tardigrade or 'water bear' – perhaps *Batillipes pennaki*, a tardigrade that was previously known in the Americas but of which a number were found in the Netherlands for the first time in 2015 by a researcher on the Oosterschelde beach. Tardigrades are the most indestructible animals on the planet. They can survive extreme cold and heat, toxins, dehydration, lack of oxygen and radiation. They have their own phylum (tardigrada) and they mostly eat plants (such as mosses) and bacteria.

fig. 1 A 'water bear' (magnification 280×).



PROTECTED BY GLASS AND FOAM

What else can you find in the sand? Diatoms, for example – tiny little organisms with glass shells that come in the most amazing shapes. Diatoms have chloroplasts but they are chromista, not plants. You will also find brown foam algae under your towel. This is one of the species that makes sea foam form on the beach. Foam algae are single-celled but they live in colonies. The foam appears when the waves whip up the layer of slime that the foam algae live in. During the daytime, foam algae produce nutrients by photosynthesis and store it in that layer of slime. The cells can then grow overnight. The slime also helps protect the foam algae against predators.

SAND UNDER THE MAGNIFYING GLASS

And what about the sand itself? Part of it is the remains of shells and animal skeletons. The internal skeleton of a cuttlefish, for instance (you can sometimes find whole ones). Hopefully no people or dogs will have peed or pooped near your beach towel, because there could then be faecal bacteria and pathogenic organisms in the sand beneath your towel, such as *Giardia lamblia* (a protozoan) that can cause stomach upsets. The other thing you could find is the slimy piles of poo from lugworms, a type of worm that eats the sand and then excretes it again.

Sometimes you may see larger organisms on the beach as well, a bit further from your towel. In 2017, one of the biggest marine mammals of all, a sperm whale, washed up on the beach in Zeeland. That's something you don't want to come up against too often!

EXERCISES

1



Figure 1 shows a tardigrade.

a Roughly how big is a tardigrade?

- ☐ A 0.0025 mm
- ☐ B 0.025 mm
- ☐ C 0.25 mm
- ☐ D 2.5 mm

b Most animals and plants that you can see with the naked eye have been discovered and classified long ago. Many microorganisms, such as tardigrades and diatoms, were only discovered and classified in large numbers more recently. The first diatoms were described in 1773 and the first tardigrade in 1783. Explain why it became possible around then.

c In 1946, the researcher Ernst Marcus discovered a new species of tardigrade. Marcus was able to confirm that this was indeed a new species by comparing the *outward appearance / the DNA*.

d In 2015, the researcher Frank Roza found various tardigrades in sand from the beach. What two methods could he have used to determine whether these 'water bears' were all the same species? Explain your answer.

2

a Does the brown foam alga have chloroplasts? Explain your answer.

b Why doesn't the brown foam alga make nutrients during the night?

c The foam alga isn't a plant and it isn't a protozoon either. What kingdom does the foam alga belong to? Explain your answer.

3

The text of this 'How it fits together' section mentions organisms from various kingdoms.

a Make a table and put all those organisms into the correct kingdoms.

b Which of the organisms in the text can photosynthesise?

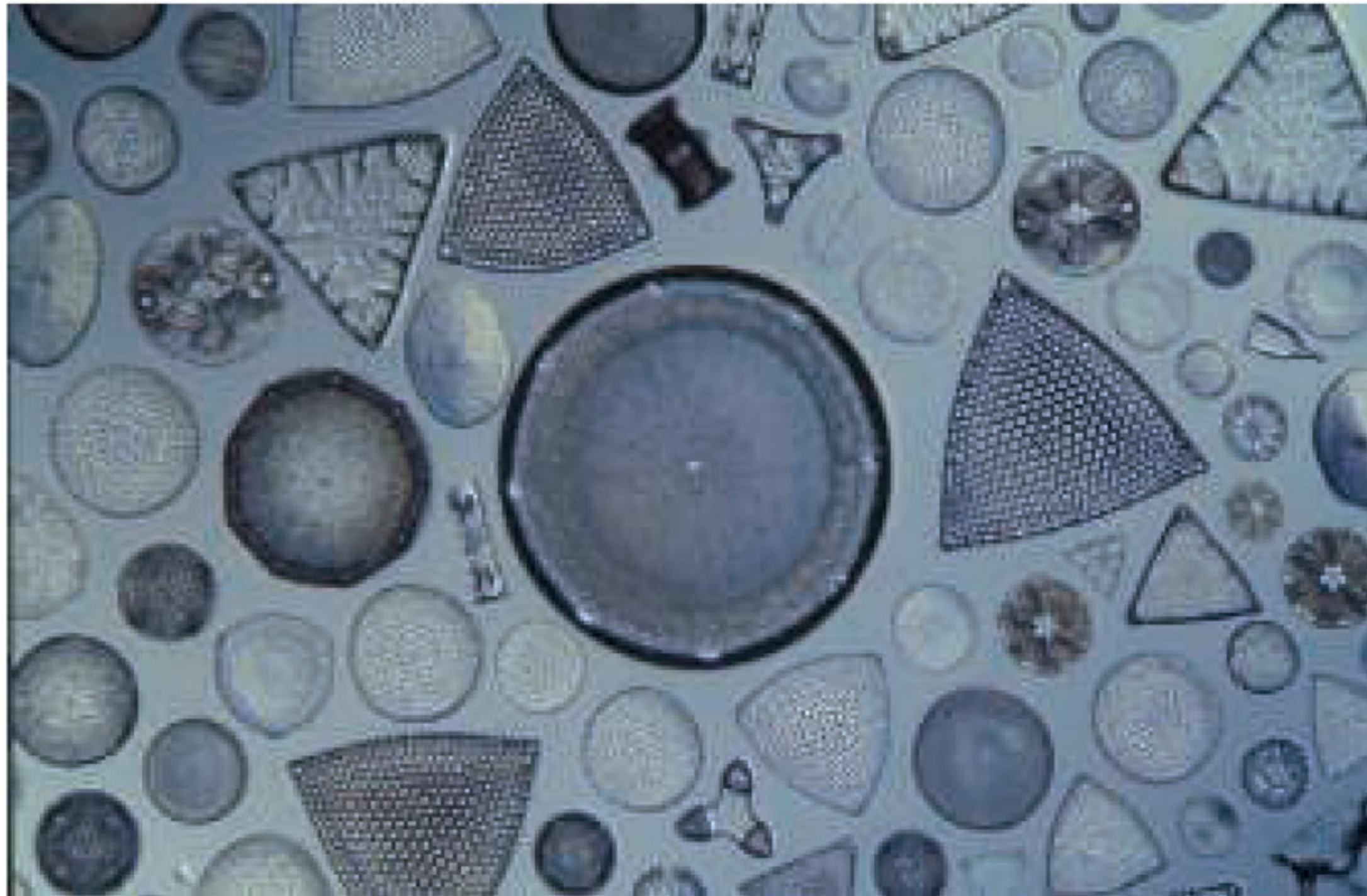
4



Figure 2 is a picture of diatoms.

- a** What kind (or kinds) of symmetry can you see in the image? Show the symmetry on the photo.

fig. 2 Diatoms



- b** Write down a radially symmetrical animal that you can find on the beach or in the sea.

5

Figure 3 shows you sand under a light microscope. Sand consists partly out of the whole or partial skeletons of organisms.

What organisms could skeletons in beach sand come from? Write down the type of skeleton and then the organisms.

fig. 3 Sand under a microscope.



7

Vertebrates

LEARNING OBJECTIVE

3.7.15 You can name the features of five groups of vertebrates and you can give examples of them.

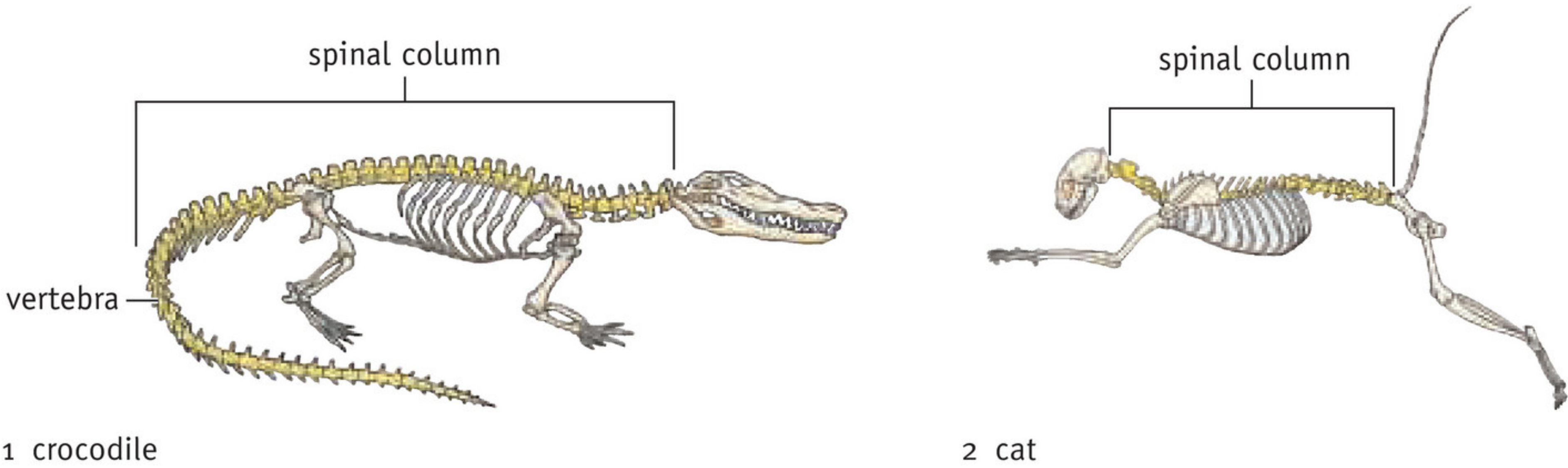
TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	3.7.15
Remembering	1, 2b
Understanding	2c
Using	2ad, 3ab, 4, 5
Analysing	

About one animal species in fifty has a backbone. These animals are the vertebrates. You are a vertebrate too.

SKELETON

Vertebrates have an endoskeleton. Part of this internal skeleton is the spinal column or backbone, which is made up of vertebrae (see figure 1).

fig. 1 Vertebrates have a spinal column with vertebrae.



FEATURES OF VERTEBRATES

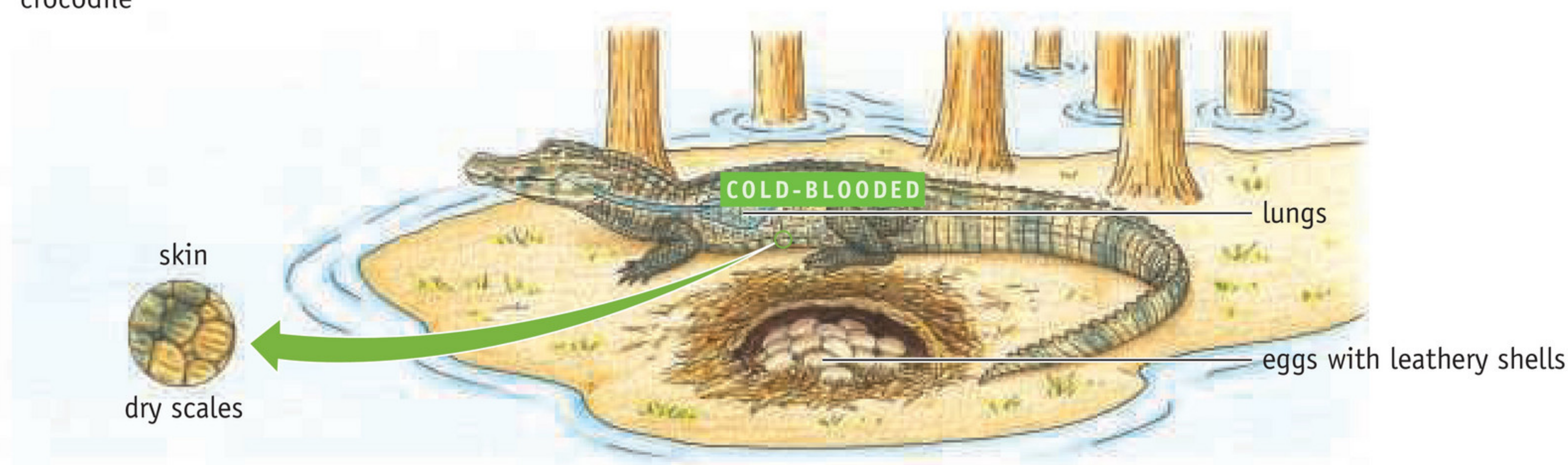
Five groups of vertebrates are fishes, amphibians, reptiles, birds and mammal (see figure 2). Amphibians, reptiles and mammals are classes. The ‘fishes’ group contains several classes. Birds are in the same class as reptiles.

fig. 2 Features of vertebrates

1 FISHES	2 AMPHIBIANS
perch gills COLD-BLOODED scales with mucus eggs with no shells	frog also breathes through the skin COLD-BLOODED lungs skin mucus external gill eggs with no shells

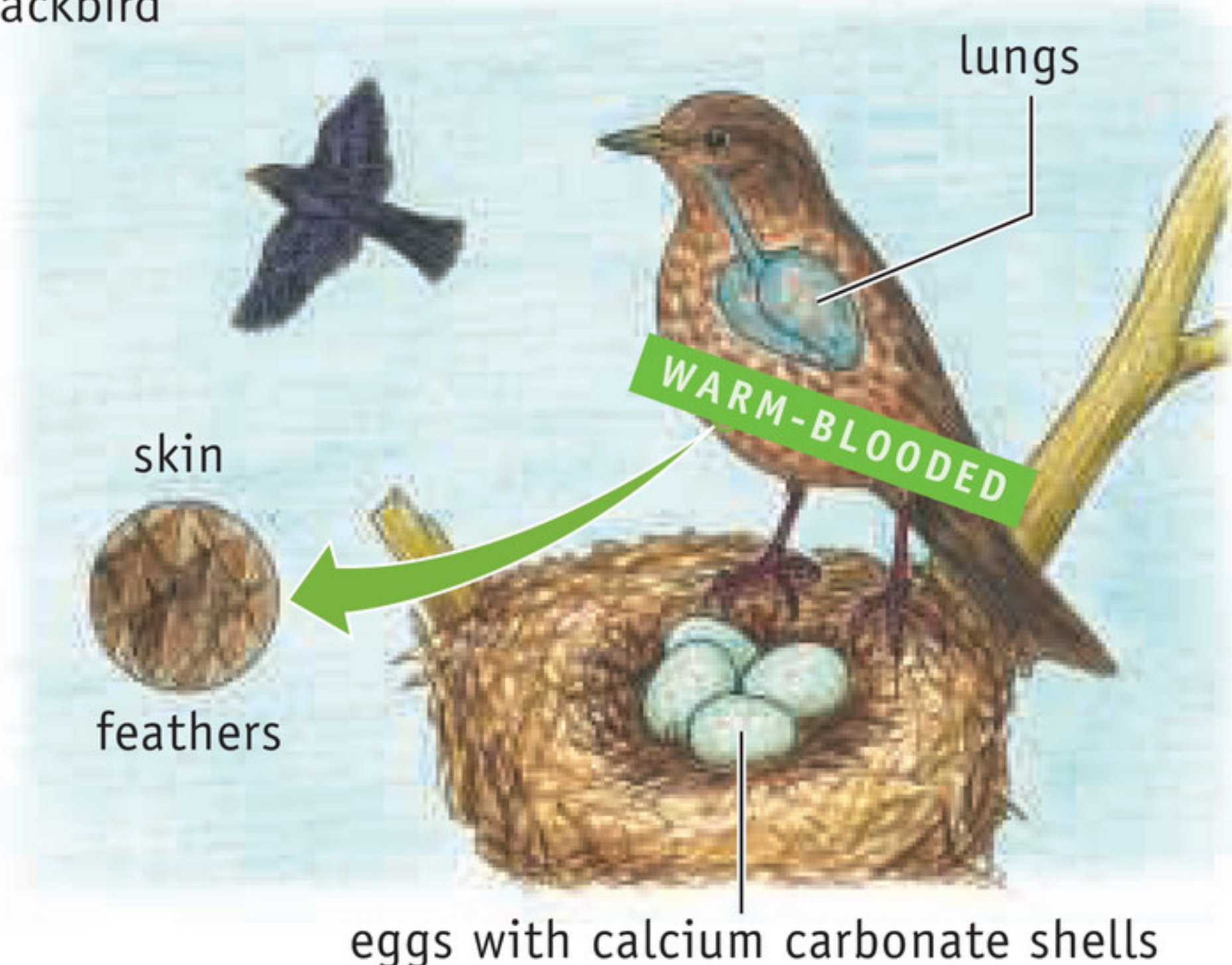
3 REPTILES

crocodile



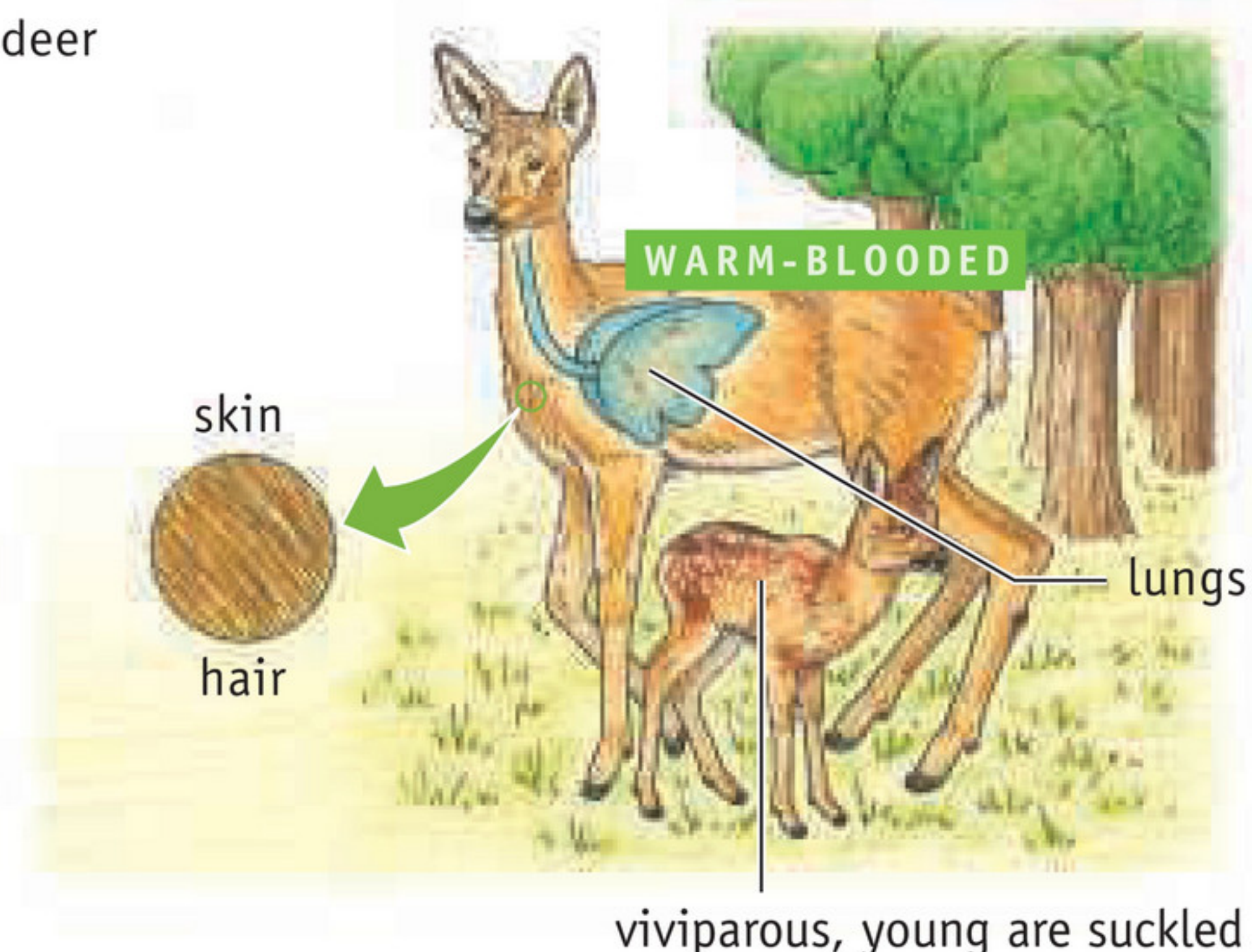
4 BIRDS

blackbird



5 MAMMALS

deer



Five features can be used to distinguish between the vertebrate classes:

- 1 *Skin*. In vertebrates, the skin is covered with scales, slime, feathers or hair.
- 2 *Body temperature* Some animals keep their body temperature up at all times (constant). These are called **warm-blooded**. Other animals have varying body temperatures that are the same as the temperature of the surroundings. They are called **cold-blooded**.
- 3 *Respiratory organs*. Vertebrates may breathe using gills or lungs. Some vertebrates can also breathe through their skin.
- 4 *Method of reproduction* Many vertebrates lay eggs. There are eggs with no shells, eggs with tough leathery shells eggs and eggs with hard calcium carbonate shells (see figure 3). In some vertebrates, the young do not hatch out of eggs but are born directly from the mother. These are known as **viviparous** animals (see figure 4). The young drink milk (**suckle**) from the mother.
- 5 *The animals' living environment*. There are vertebrates that live in the water, on land or in the air. Some vertebrates can live both on land and in the water. Virtually all mammal species live (primarily) on land. But some mammals do live in the water (see figure 5).

fig. 3 Vertebrate eggs.



1 eggs with no shell, from a frog (frogspawn)



2 eggs with a leathery shell, from a snake



3 eggs with a calcium carbonate shell, from a blackbird

fig. 4 Dolphins are viviparous.



fig. 5 Mammals that live in the water are an exception.



1 whale



2 seal

EXERCISES

1

- a What is the body temperature of these vertebrates?

1 fishes

constant / not constant – cold-blooded / warm-blooded

2 amphibians

constant / not constant – cold-blooded / warm-blooded

3 reptiles

constant / not constant – cold-blooded / warm-blooded

4 birds

constant / not constant – cold-blooded / warm-blooded

5 mammals

constant / not constant – cold-blooded / warm-blooded
- b What is the skin of these animals covered with?

1 fish

.....

2 amphibians

.....

3 reptiles

.....

4 birds

.....

5 mammals

.....
- c What environments do the animals (mostly) live in?

1 fishes

land / air / water

2 amphibians

land / air / water

3 reptiles

land / air / water

4 birds

land / air / water

5 mammals

land / air / water
- d Which groups of vertebrates breathe (at some point in their lives) with lungs?

fishes / amphibians / reptiles / birds / mammals

e How do the animals reproduce? Choose between: *eggs with calcium carbonate shells* – *eggs with leathery shells* – *eggs with no shells* – *viviparous*.

- 1 fishes
- 2 amphibians
- 3 reptiles
- 4 birds
- 5 mammals

2

- a The skin of warm-blooded animals is covered with hair or feathers, but that is not the case for cold-blooded animals.
Explain why.
- b Some vertebrates breathe using lungs and others using gills.
Which organs do animals that live in the water generally use to breathe?
gills / lungs
- c Some vertebrates lay eggs that do not have shells.
Where do these animals lay their eggs: on land or in the water? Explain your answer.
- d There are exceptions. An ostrich is not able to fly, for example, and so it lives on the land and not in the air. A whale is a mammal, but large parts of its skin are not covered with hairs. A whale does not have fur – just a few hairs.
Figure 6 shows you three more exceptions to the features you have learned for the class of vertebrates.
What exceptions can you see?

fig. 6



1 hippopotamus (mammal)



2 kiwi (flightless bird)



3 armadillo (mammal, lives on land)

3

- Read the text entitled “DNA of the platypus mapped out”.
- a What two features of mammals does a platypus have?
 - b Which feature of reptiles does a platypus have?

fig. 7

DNA of the platypus mapped out

The duck-billed platypus is a curious beast. The animal has fur, a beak that looks like a duck’s, and it lays eggs with a leathery shell. Even so, young platypuses suckle from special milk glands in the mother’s skin. So the platypus has features from various groups of vertebrates. Researchers wondered which group of vertebrates the DNA of the platypus would be most similar to. The platypus has so far always been classified with the mammals. The researchers therefore expected that platypus DNA would be most similar to the DNA of mammals. In their research, they mapped out the platypus DNA and compared it against DNA from animals from various groups of vertebrates. Platypus DNA turned out to be about an 80% match for mammalian DNA.

Source: *Nature* 2008.



4

- a Table 1 lists the approximate numbers of species known for each class of the vertebrate phylum.
 - Add up the total number of vertebrate species and fill that number in the table.
 - For each vertebrate group, work out what percentage of the total number of species it contains. Write the percentages down in the table.
 - Check that those percentages add up to 100%.

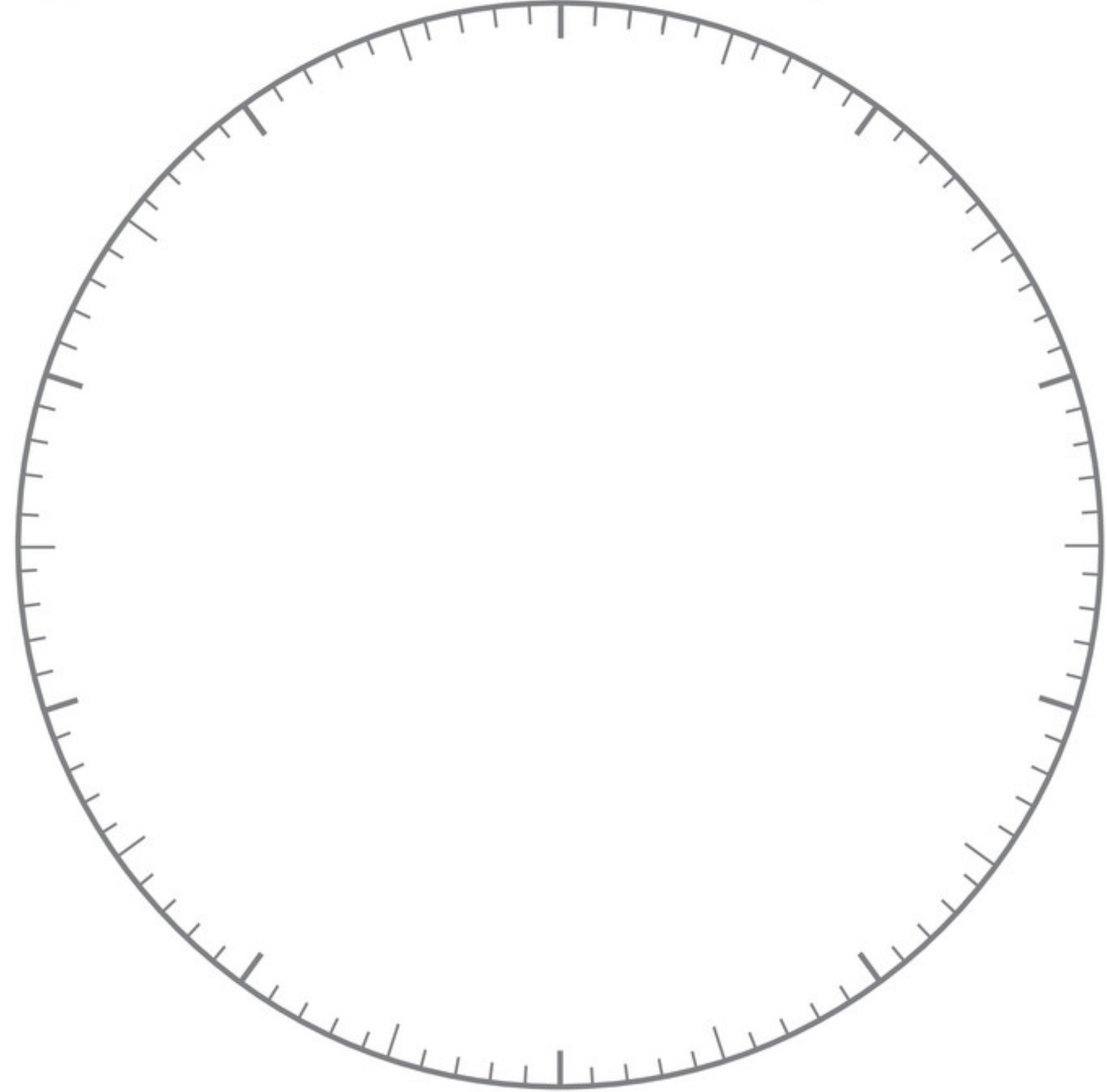
Table 1

Group	Number of species	Percentage
fishes	20,000	
amphibians	2000	
reptiles	6000	
birds	8000	
mammals	4000	
total		100%



- b Draw the percentages you found in on the pie chart in figure 8.
 - Colour the sections in using different colours.
 - Label each section to show which group of vertebrates it represents.

fig. 8 Pie chart showing the percentage of vertebrate species in each group.

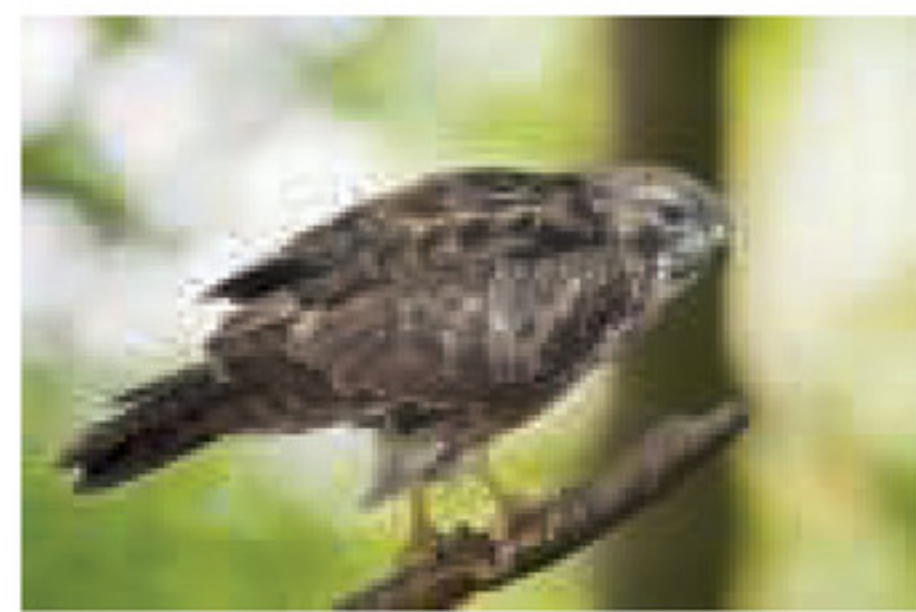
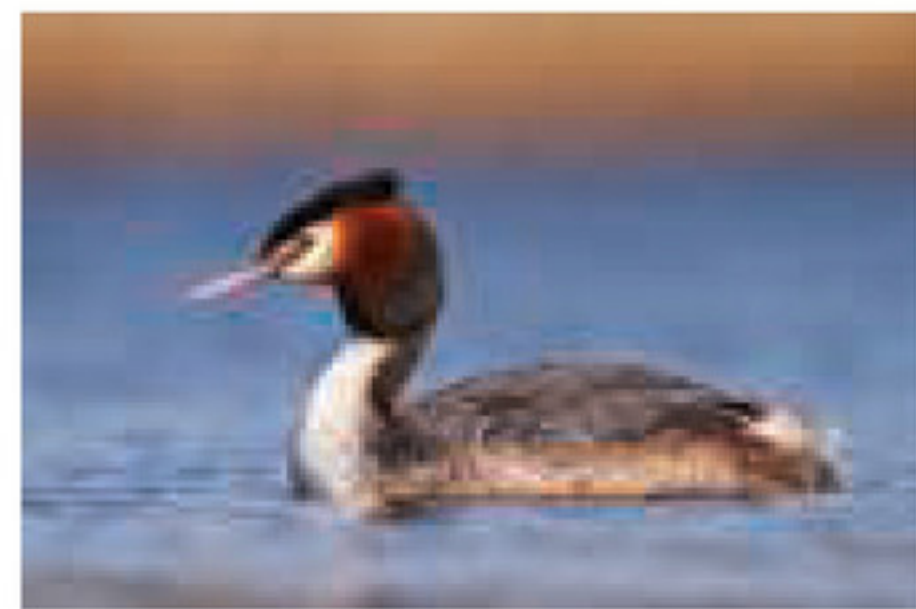
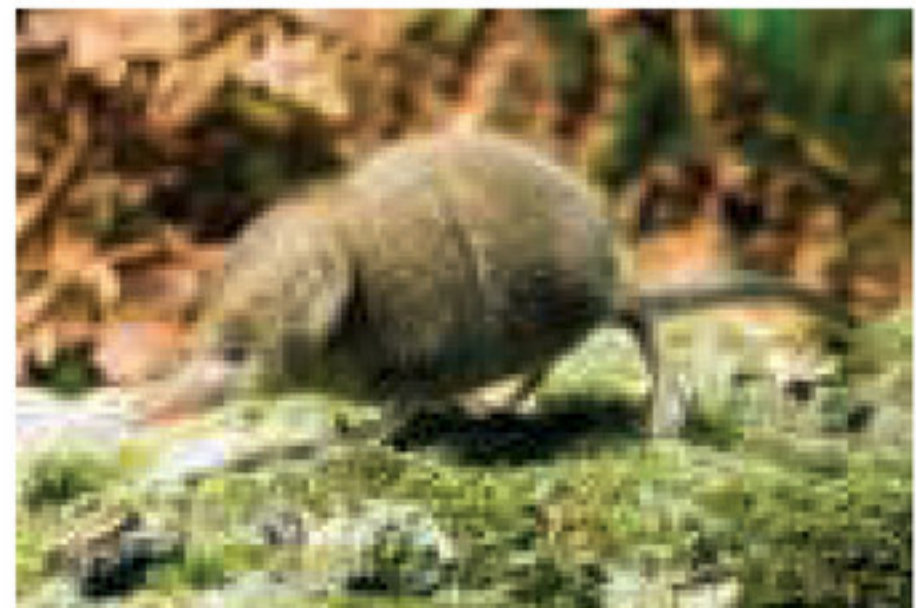
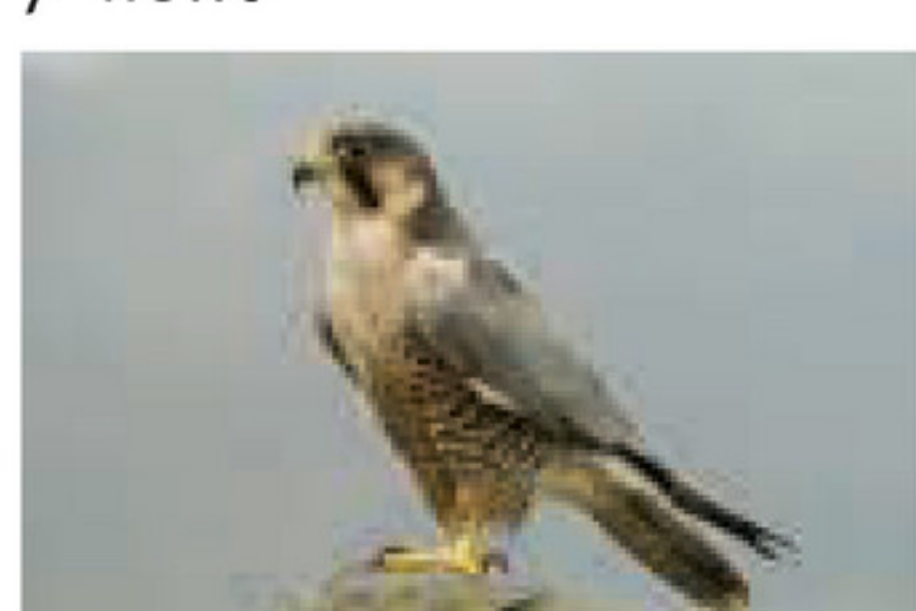
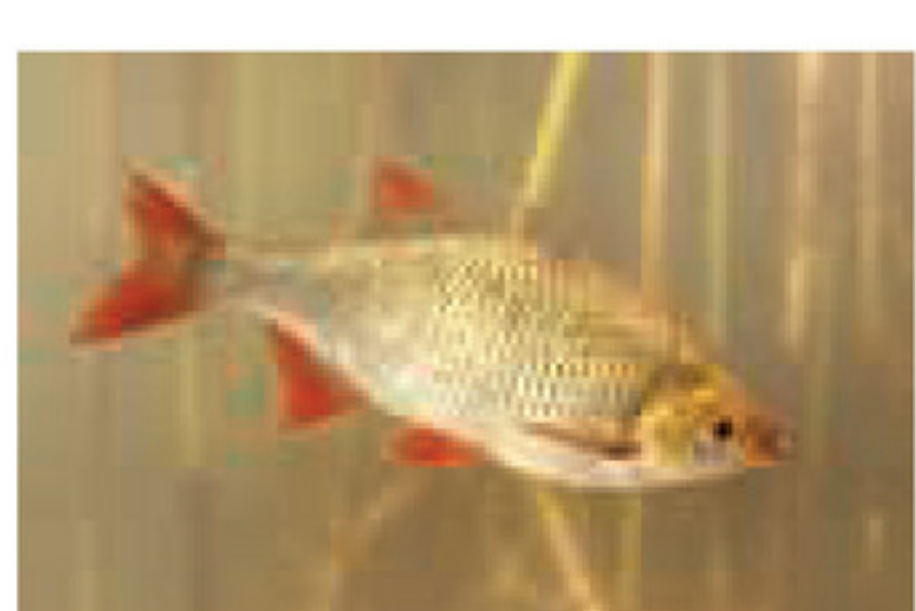


5

Make a table with five columns: fishes / amphibians / reptiles / birds / mammals.
Put the following animals in the correct columns in your table. Use figures 2 and 9 to help work out your answers.

buzzard – badger – squirrel – hedgehog – magpie – trout – grebe – goose – shark – lizard – herring – cod – frog – crow – crocodile – mole – hippopotamus – stork – toad – eel – heron – newt – tortoise – plaice – snake – pike – shrew – starling – stickleback – falcon – bat – roach – whale – weasel

fig. 9 Vertebrates in the Netherlands.

		
1 buzzard	2 magpie	3 trout
		
4 grebe	5 cod	6 toad
		
7 newt	8 plaice	9 shrew
		
10 falcon	11 roach	12 weasel

8 Arthropods

LEARNING OBJECTIVE

3.8.16 You can name the features of five groups of arthropods and you can give examples of them.

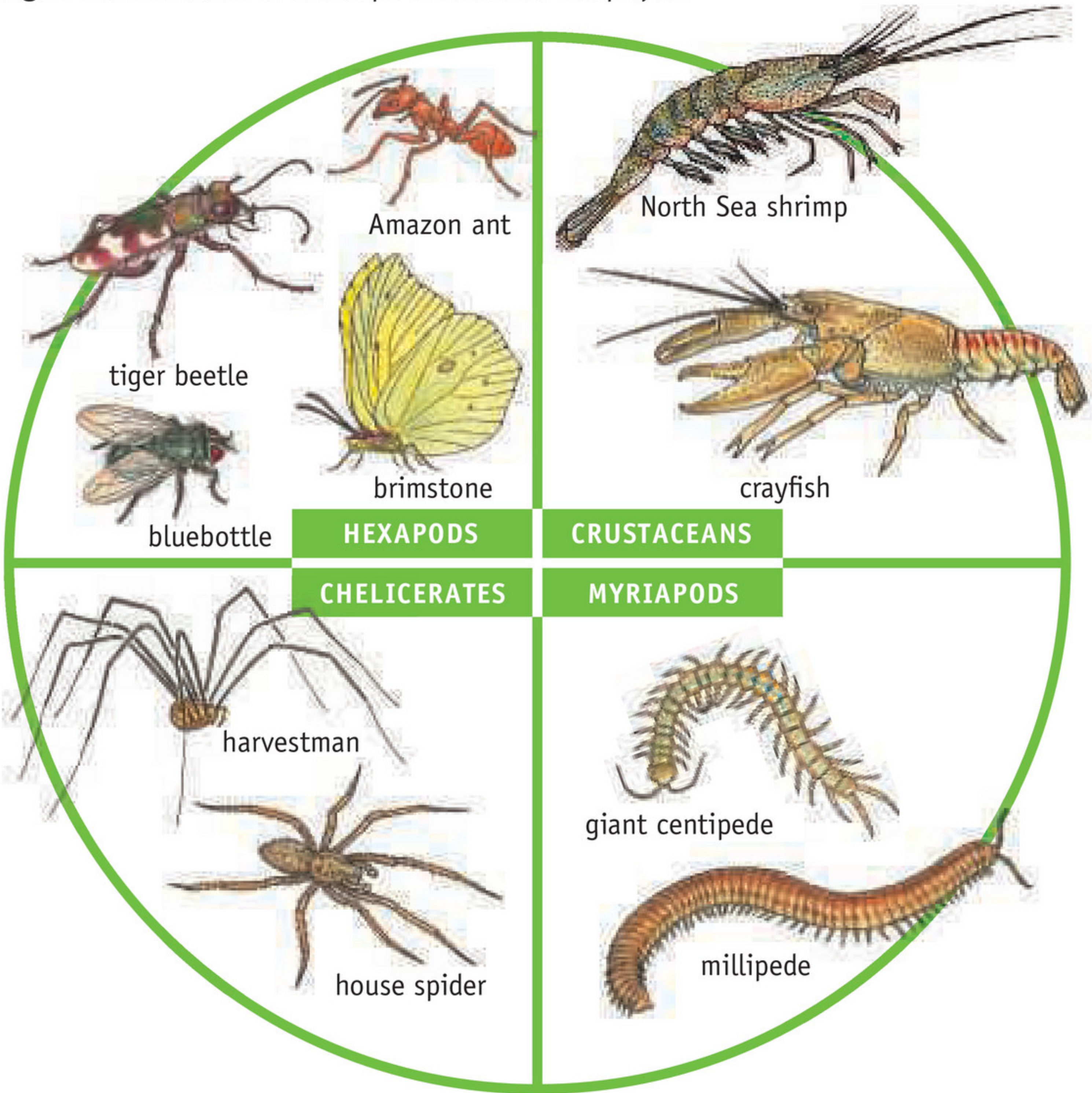
TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	3.8.16
Remembering	1de, 2
Understanding	1bc
Using	1a, 3, 4
Analysing	

Enormous numbers of arthropods walk, crawl and fly all over the planet. About three out of every five animal species is an arthropod. That means there are more than a million species!

FOUR GROUPS

The arthropod phylum is subdivided into seventeen classes that you can classify in four large subphyla (see figure 1). Examples of arthropod classes are insects (hexapods), spiders (chelicerates), higher crustaceans (crustaceans) and centipedes (myriapods).

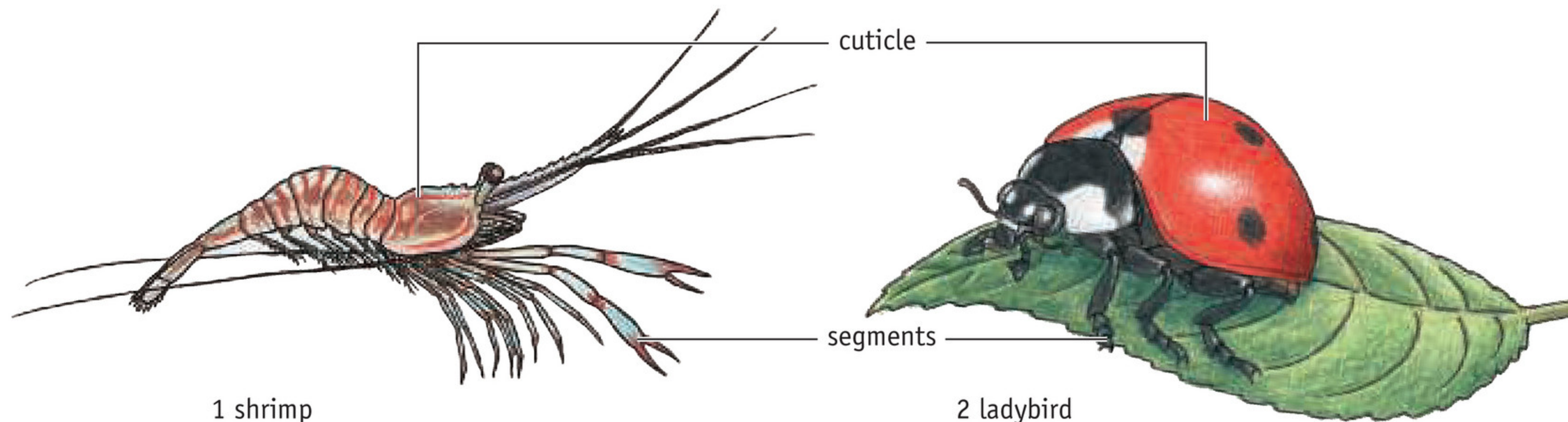
fig. 1 Classification of arthropods into four subphyla.



STRUCTURE

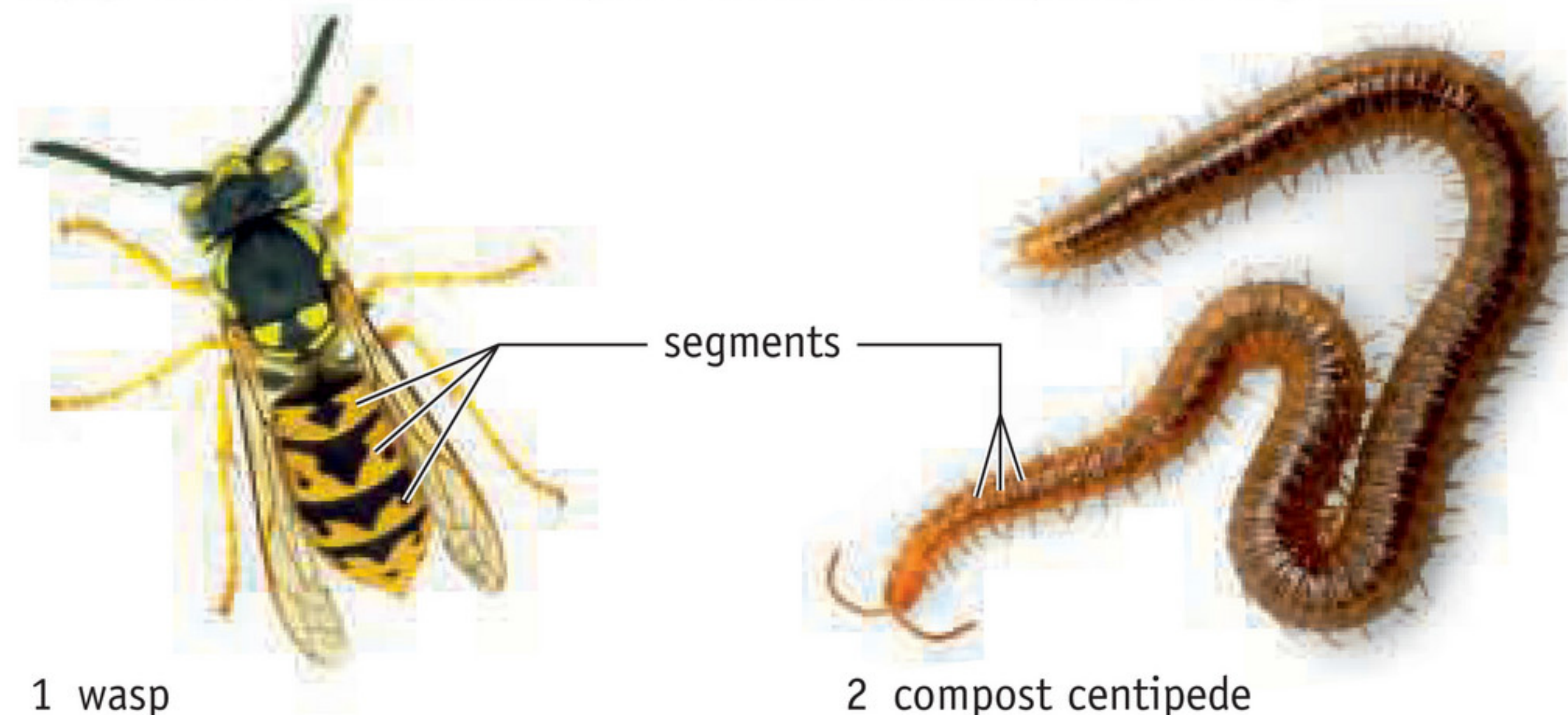
Arthropods have an external skeleton (cuticle) as a kind of armour around them. The legs of arthropods are jointed. This means that they are made up of smaller sections, the **leg segments** (see figure 2).

fig. 2 An arthropod has a cuticle and segmented legs.



The bodies of arthropods are also segmented: they are made up of **body segments**. In many arthropods, such as insects, only the abdomen (the rear part) consists of segments (see figure 3.1). In myriapods, the entire body consists of segments (see figure 3.2). There are legs on each segment. Crustaceans have ten or more legs (see figure 1) and arachnids have eight legs.

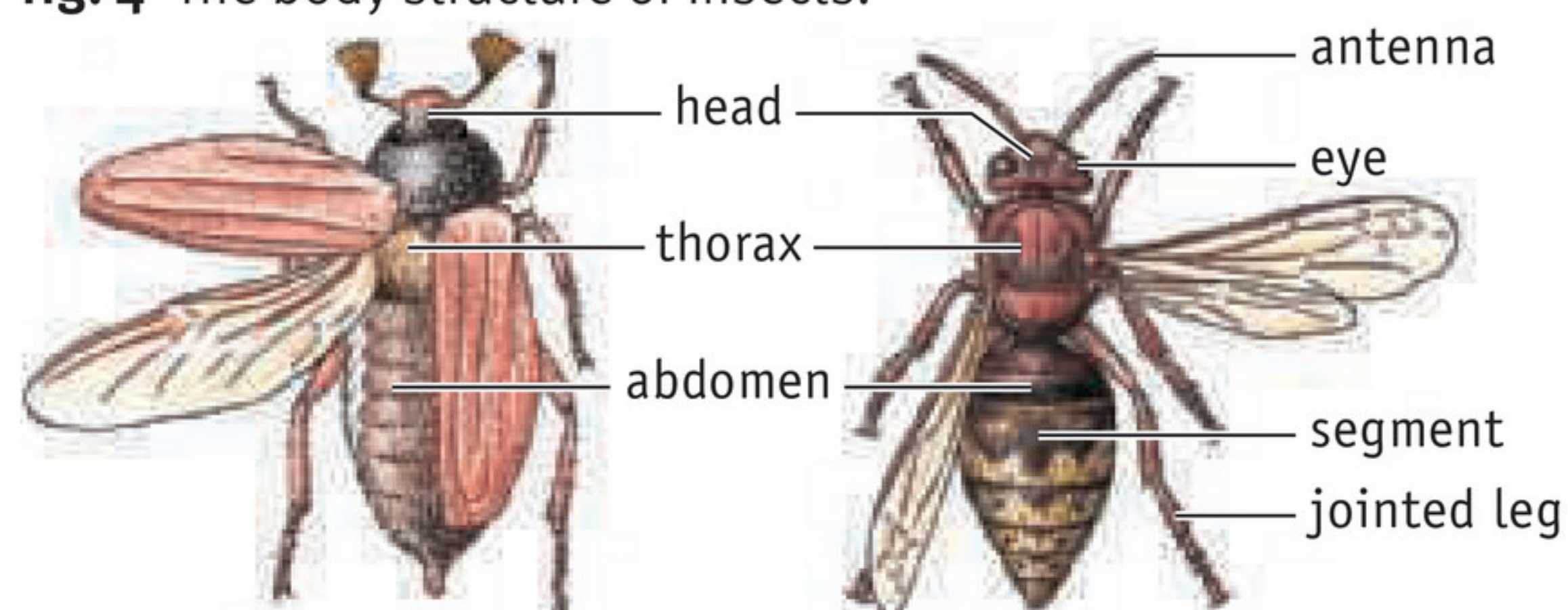
fig. 3 The body of an arthropod consists (at least partly) of segments.



INSECTS

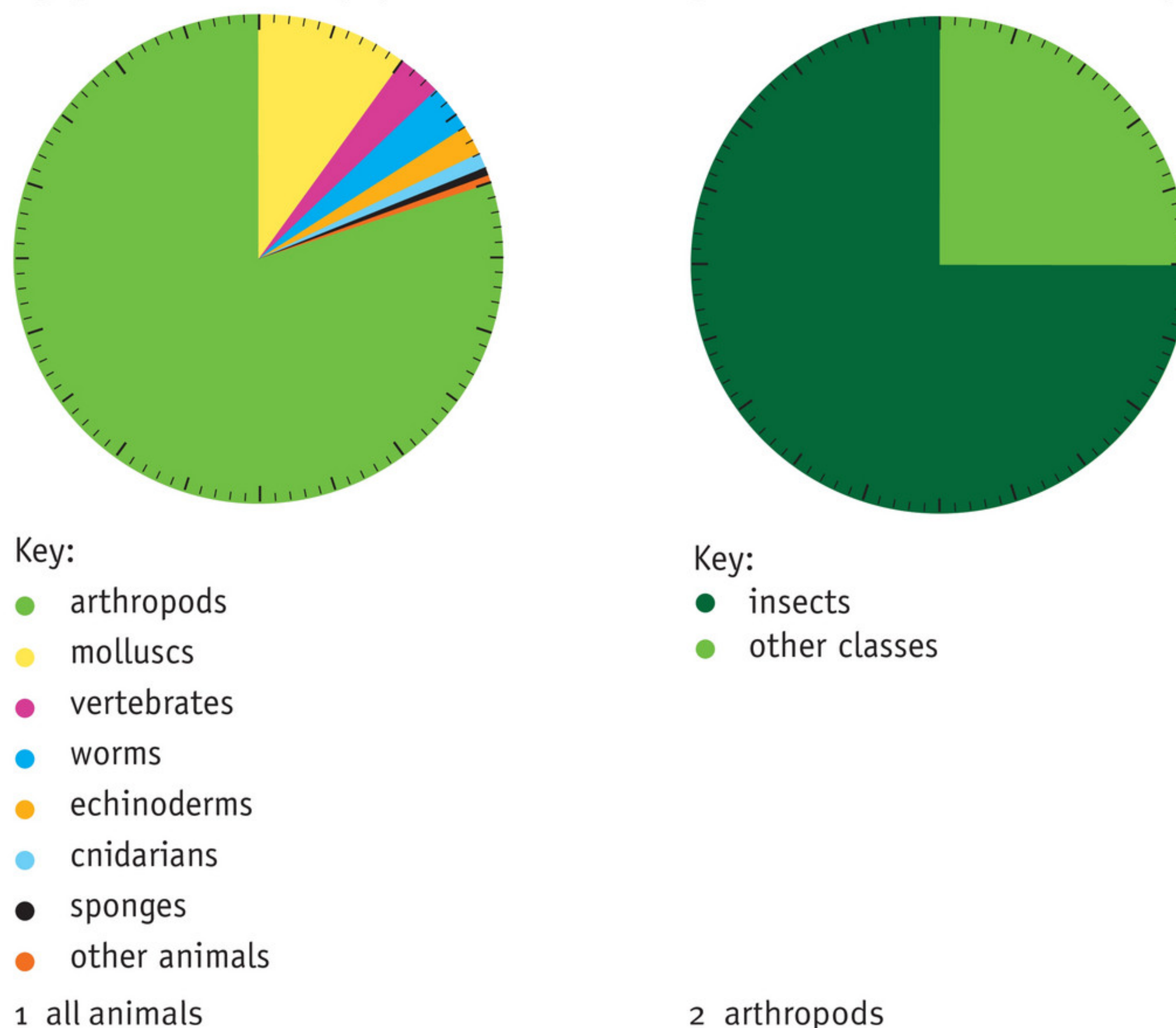
The body of an insect is made up of a **head**, a **thorax** and an **abdomen** (see figure 4). The head has eyes and antennae. There are legs on the thorax and, in most insect species, wings as well.

fig. 4 The body structure of insects.



There are more than a million species of arthropods. About 75% of arthropod species belong to the class of insects. Figure 5 shows two pie charts, one showing how the numbers of species are distributed in the animal kingdom and the other showing the distribution within the arthropod phylum

fig. 5 Distribution of phyla in the animal kingdom and classes in the arthropod phylum.



EXERCISES

1

Figure 6 shows a dragonfly. A dragonfly is an arthropod.

a What five features show you that?

- ☐ A the skin is covered with spines or nodules
- ☐ B an internal skeleton
- ☐ C the body is made up of segments
- ☐ D it is asymmetrical
- ☐ E the legs are made up of segments
- ☐ F the skeleton is a protective cuticle
- ☐ G it is bilaterally symmetrical
- ☐ H it has an external skeleton
- ☐ I it is radially symmetrical

b Explain how you can see from the body structure of a dragonfly that it can be classified as a hexapod.

c Which part of the body of a dragonfly are the legs and wings attached to?

d What gives rigidity to the body shape of an arthropod?

e In which arthropods does the entire body consist of segments?

fig. 6 A dragonfly.**2**

How many legs do the various subgroups of arthropods have?

- | | |
|----------------|--|
| 1 hexapods | <i>six / eight / ten or more / a pair on each body segment</i> |
| 2 chelicerates | <i>six / eight / ten or more / a pair on each body segment</i> |
| 3 crustaceans | <i>six / eight / ten or more / a pair on each body segment</i> |
| 4 myriapods | <i>six / eight / ten or more / a pair on each body segment</i> |

3

Figure 5 has a pie chart showing the distribution of the numbers of species per phylum of the animal kingdom and of the insects within the arthropod phylum. Each mark represents 1%.

- a** Which phylum of the animal kingdom contains the largest number of species?

.....

- b** What percentage of all animal species belong to this phylum?

- c** About 1.3 million animal species are known in total. Roughly how many species of arthropods are there?

.....

- d** Roughly what percentage of all arthropod species are insects?

- e** Roughly how many insect species are known?

.....

- f** Most of the animal species you know are vertebrates. There are not all that many species of vertebrates, however.

What percentage of all animal species are vertebrates?

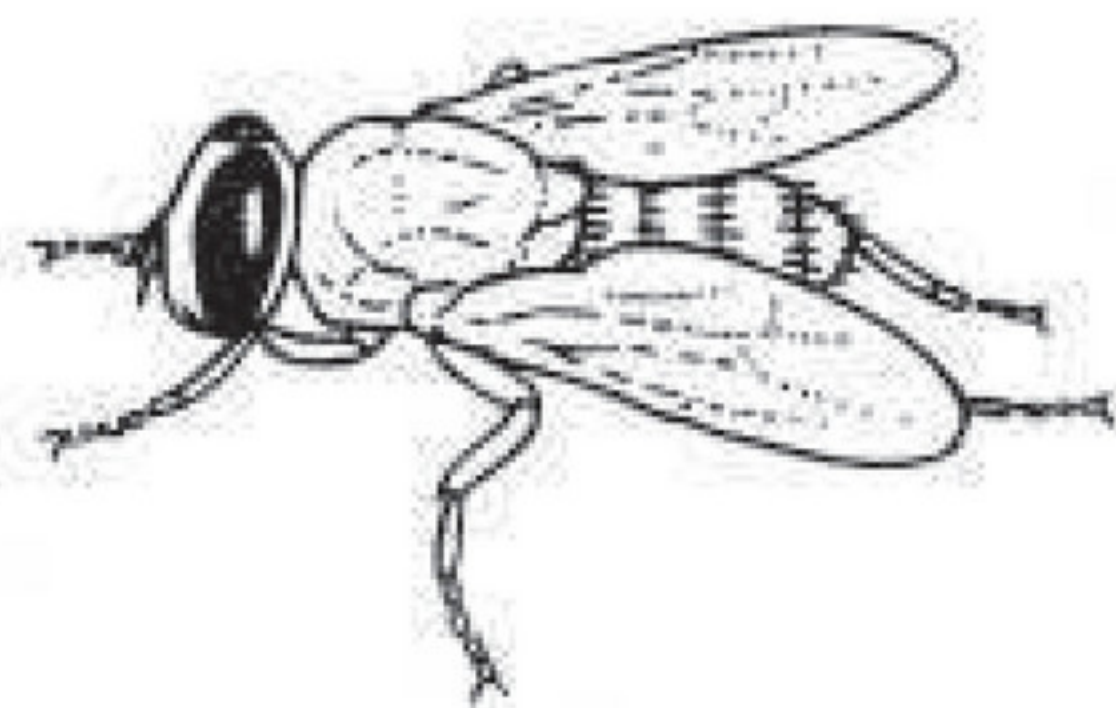
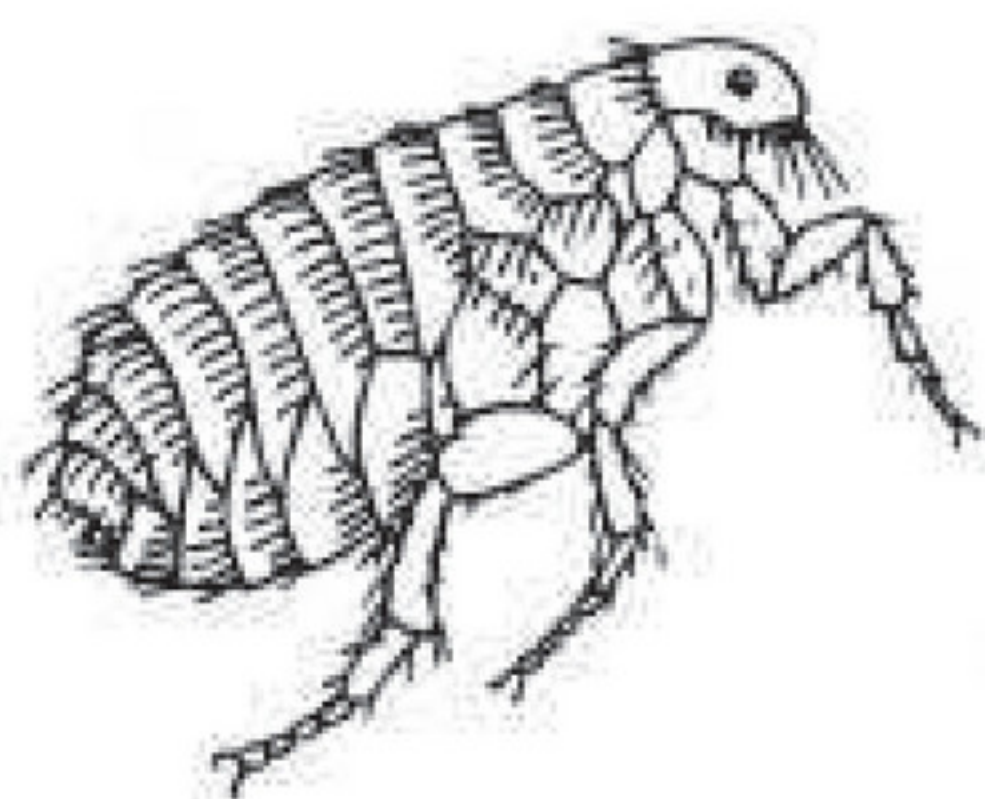
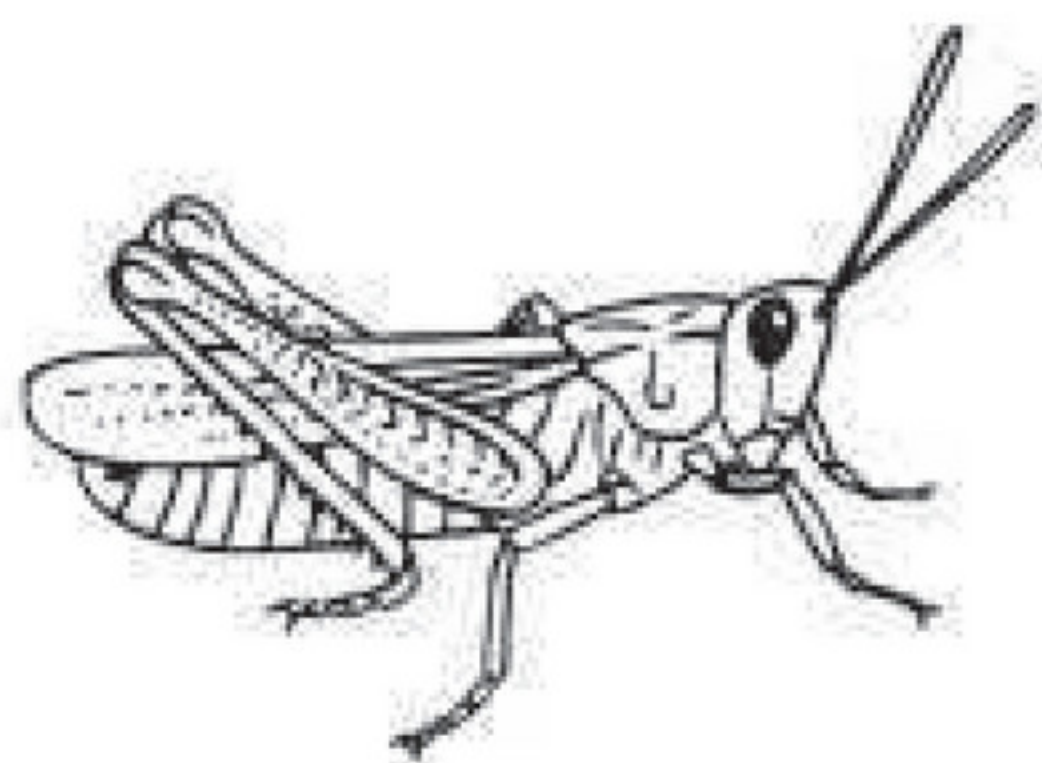
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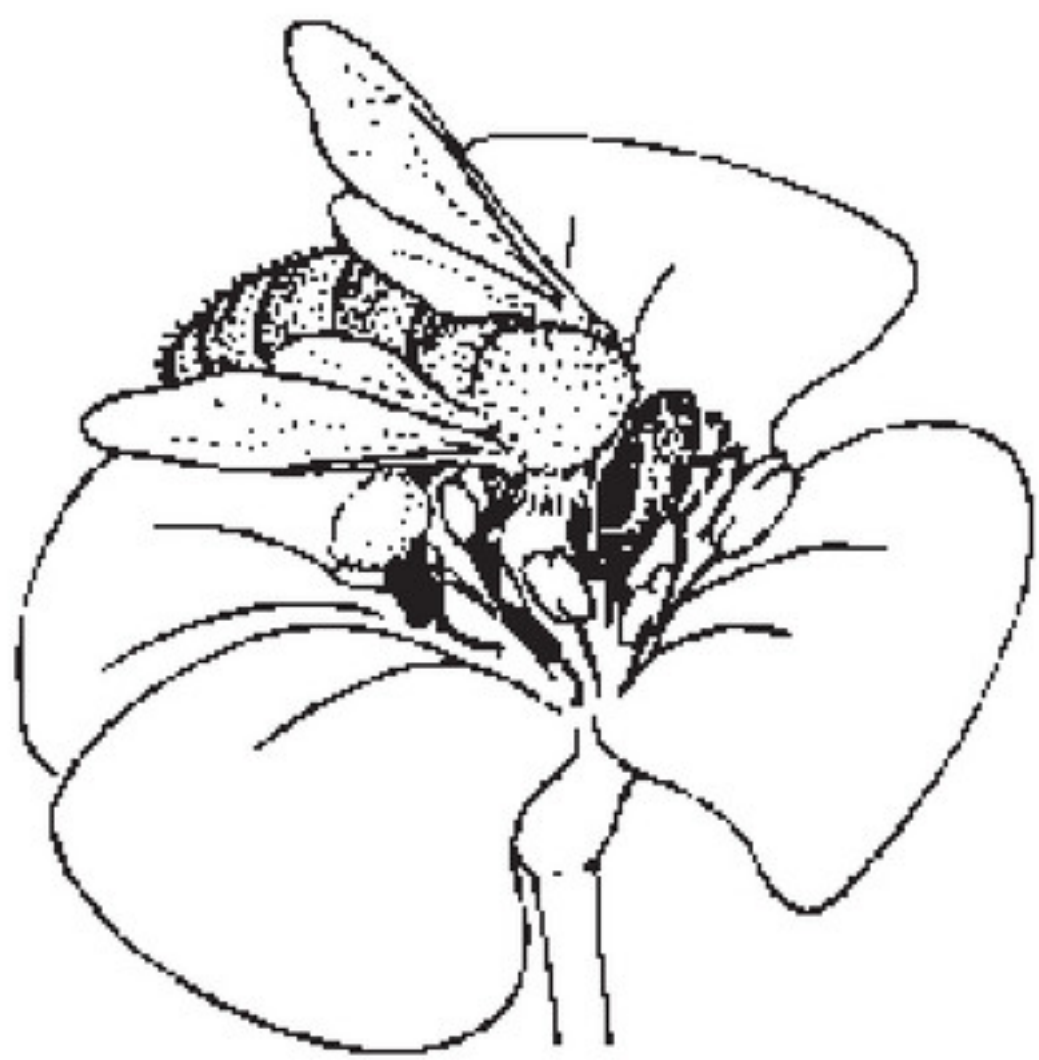
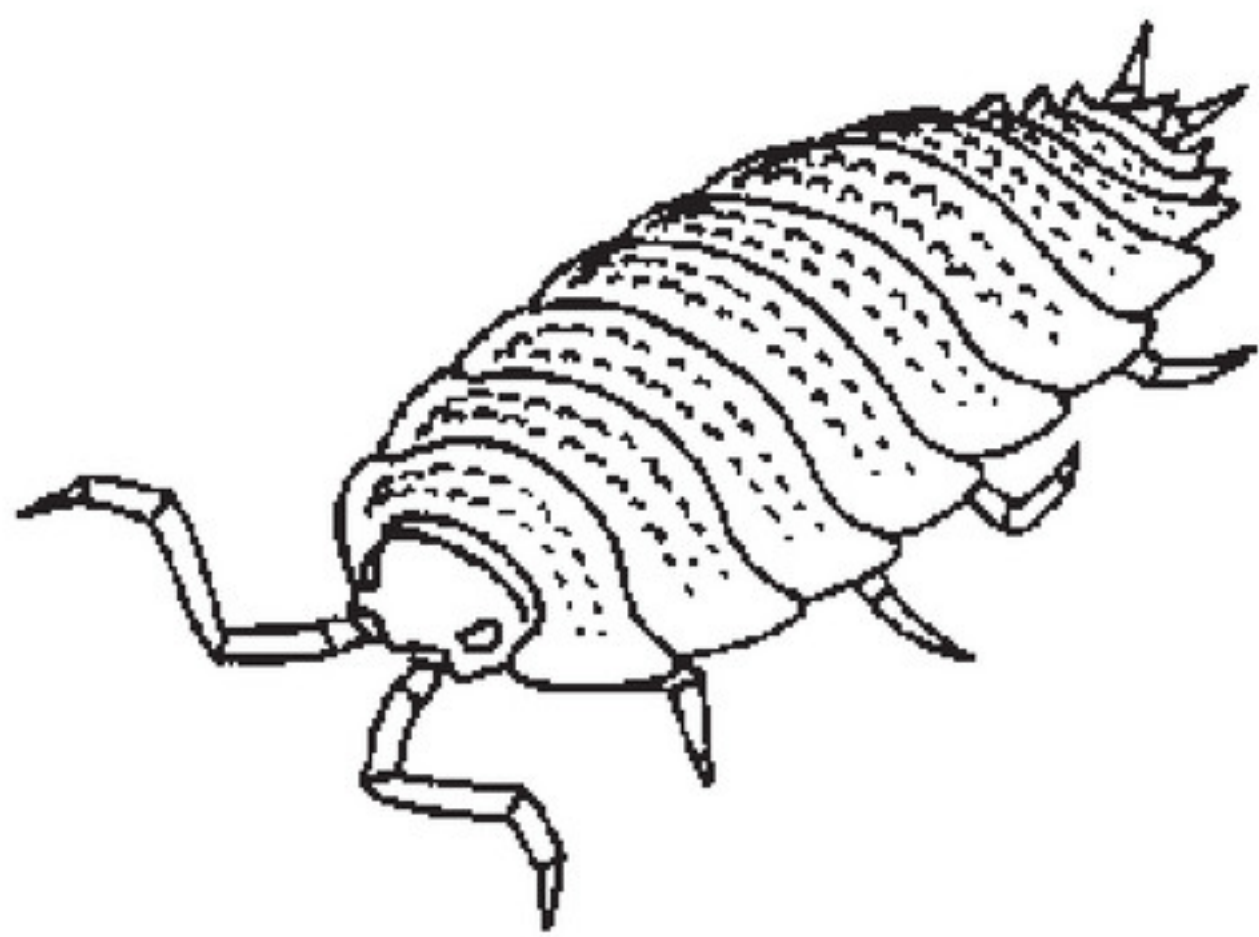
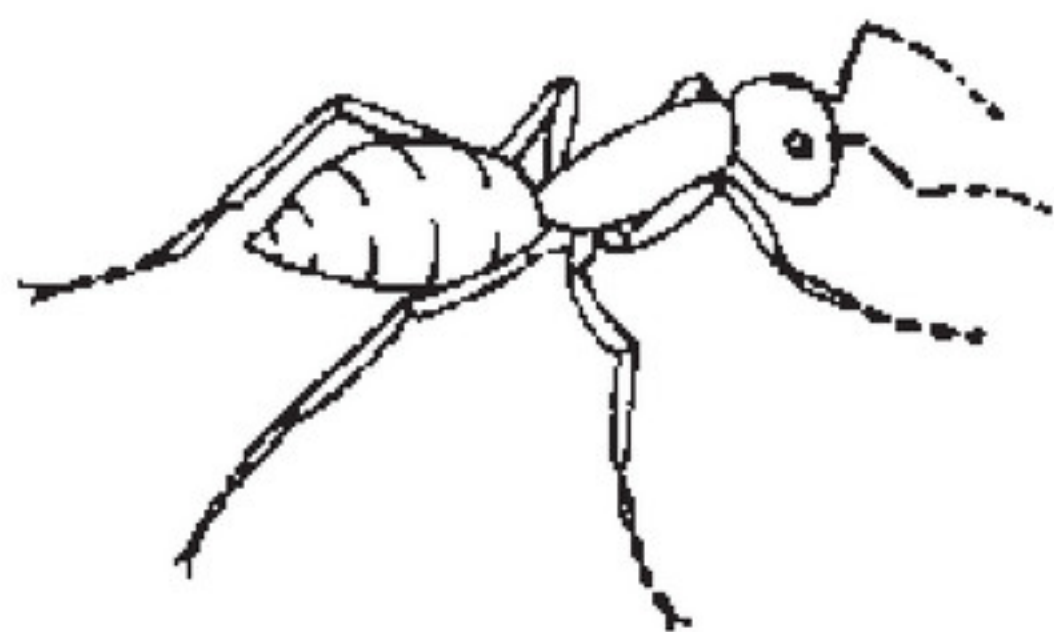
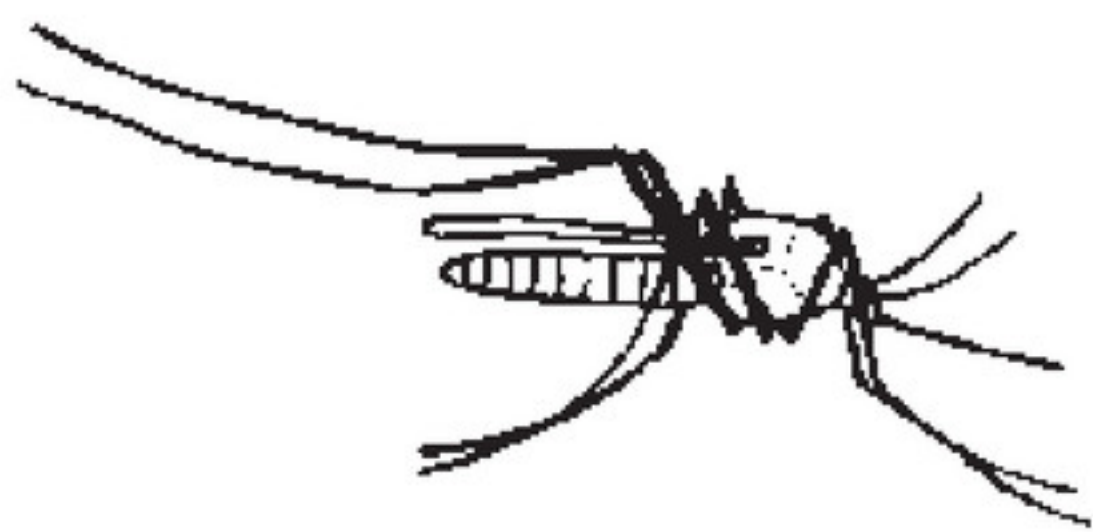
Use the worksheet on pages 259 to 261 for this exercise.

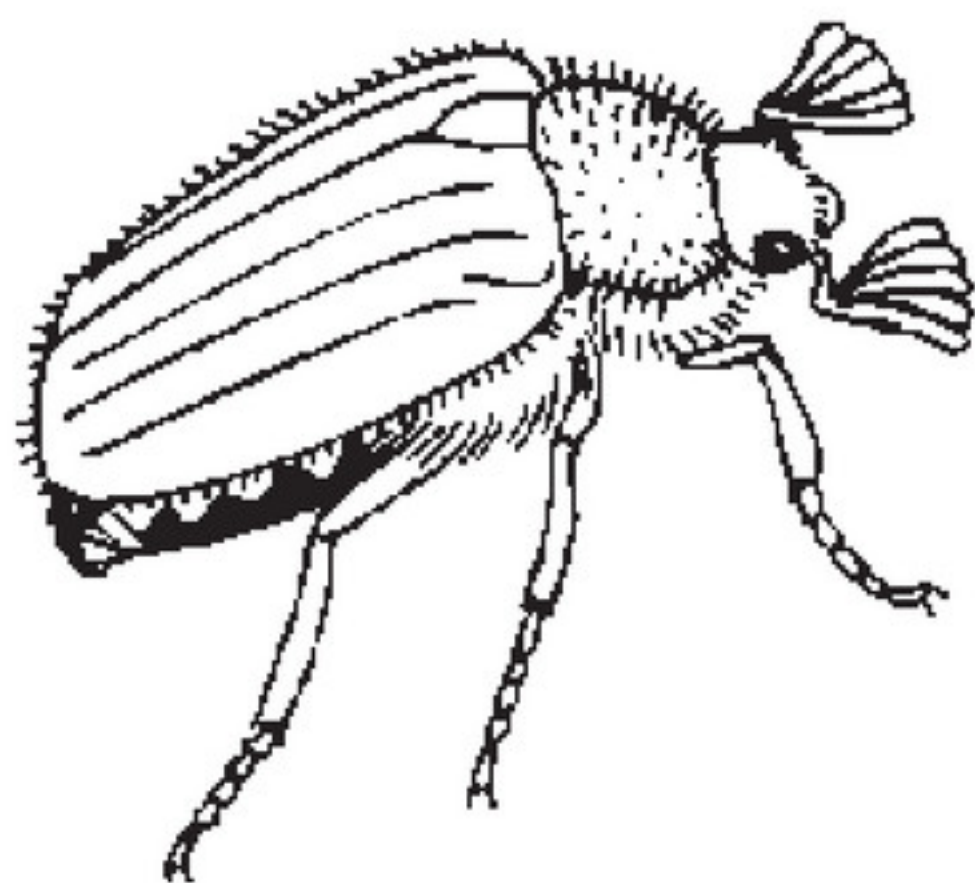
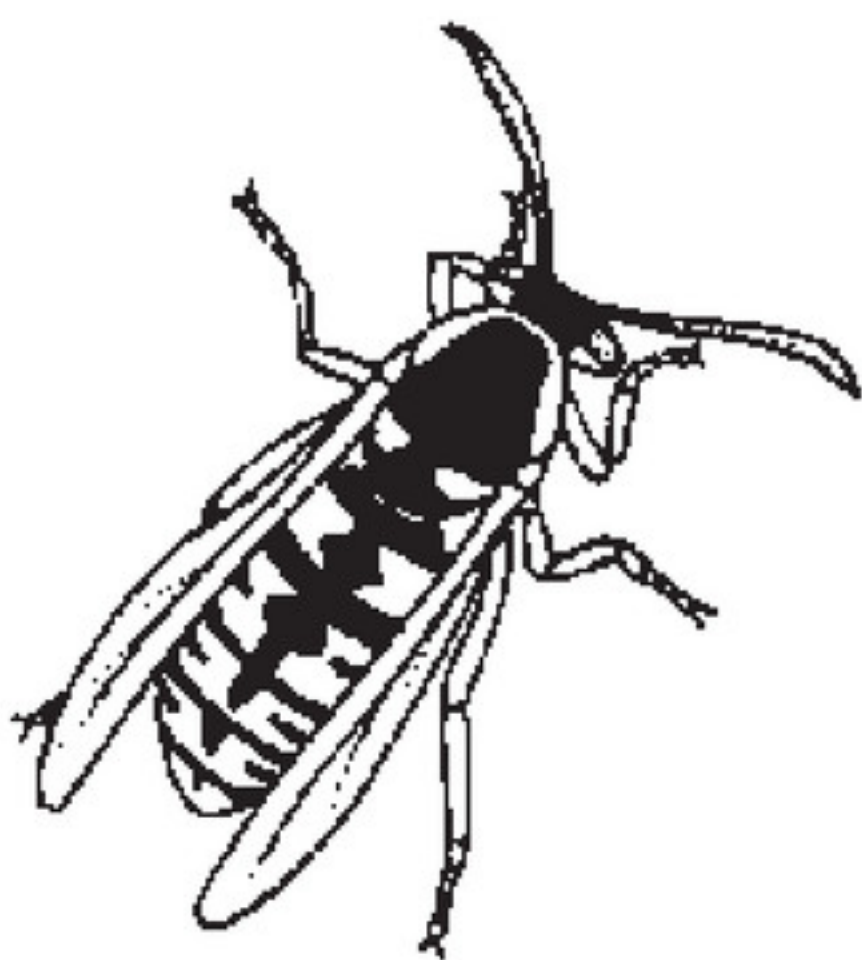
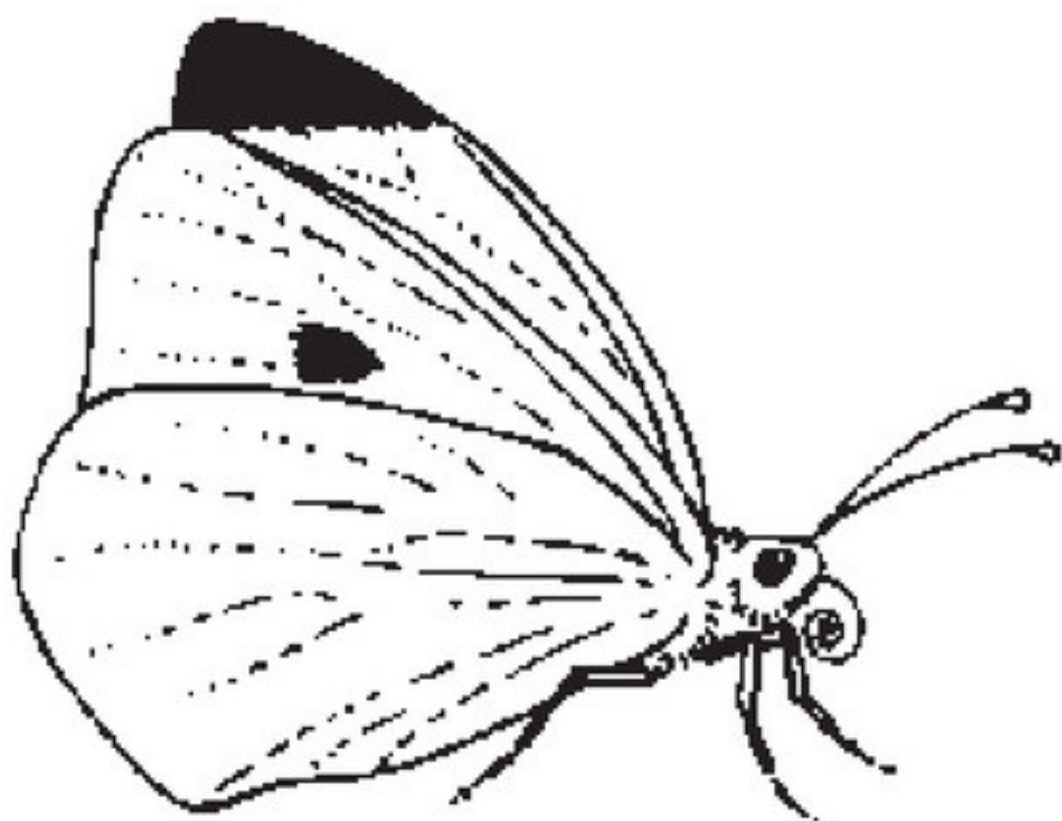
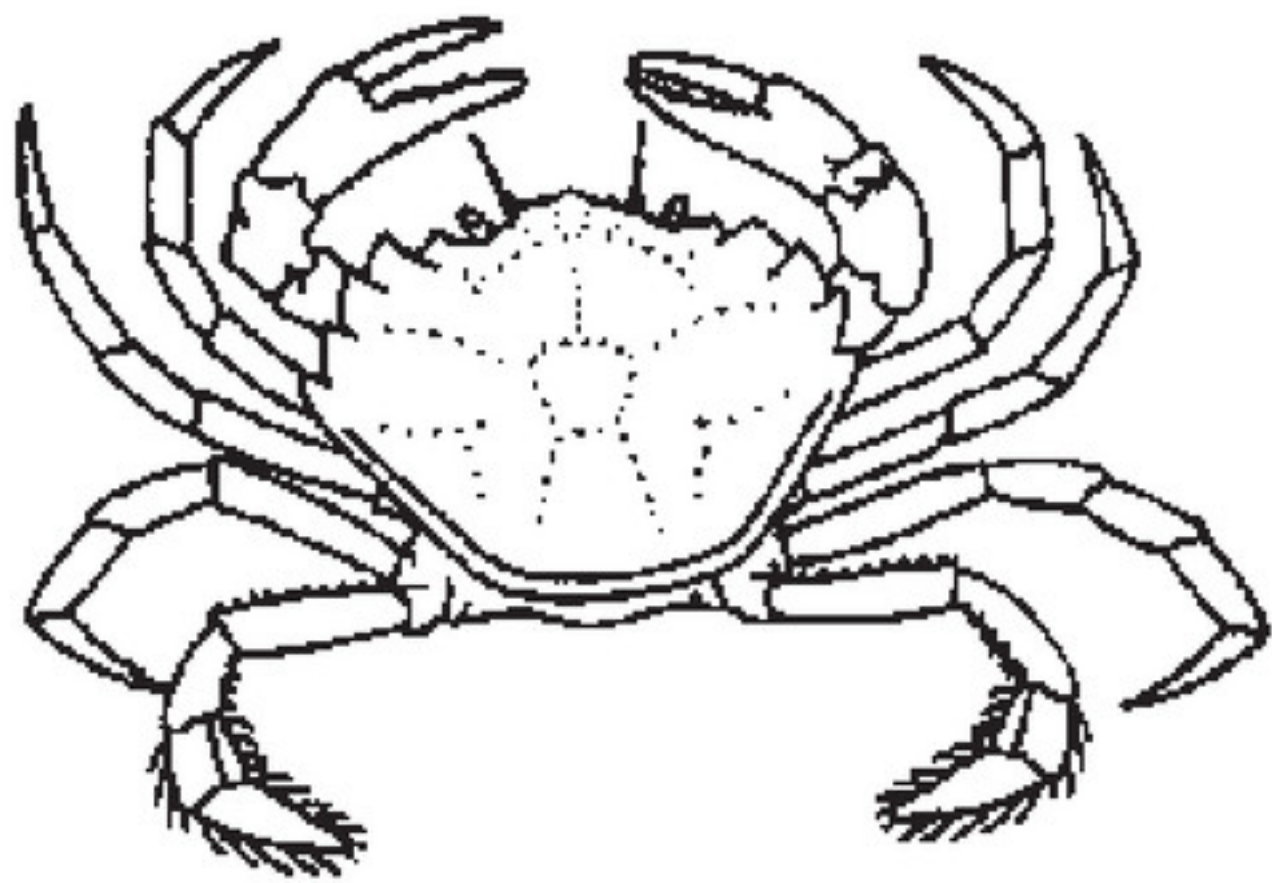
Figure 7 shows you drawings of seventeen arthropods. The worksheet gives a brief description of each of these arthropods.

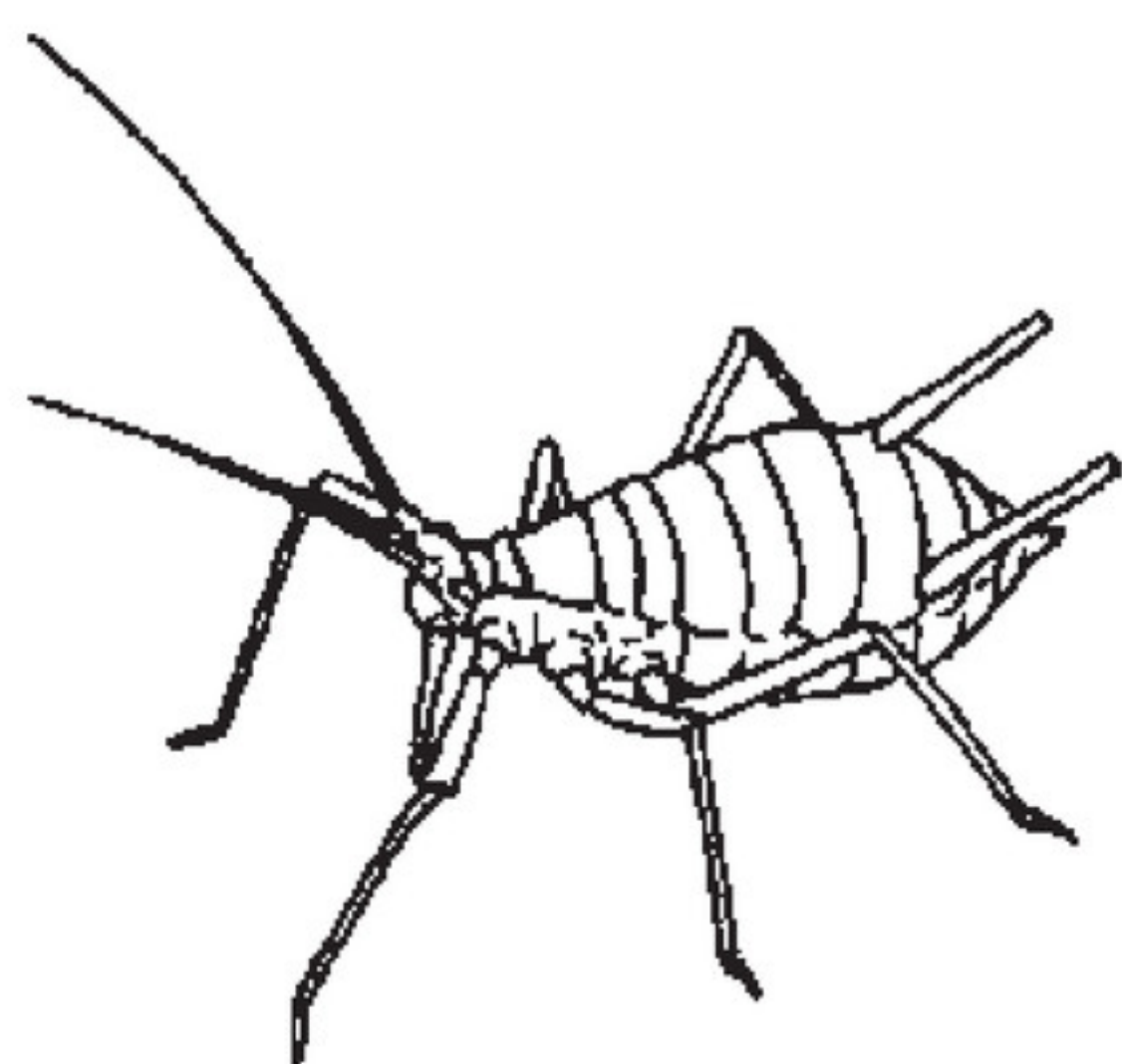
- Put the correct description next to each animal.
- Put the correct name next to each animal. Choose between: *ant* – *aphid* – *bee* – *beetle* – *butterfly* – *centipede* – *crab* – *dragonfly* – *fly* – *flea* – *garden spider* – *grasshopper* – *ladybird* – *mosquito* – *wasp* – *water flea* – *woodlouse*.

fig. 7

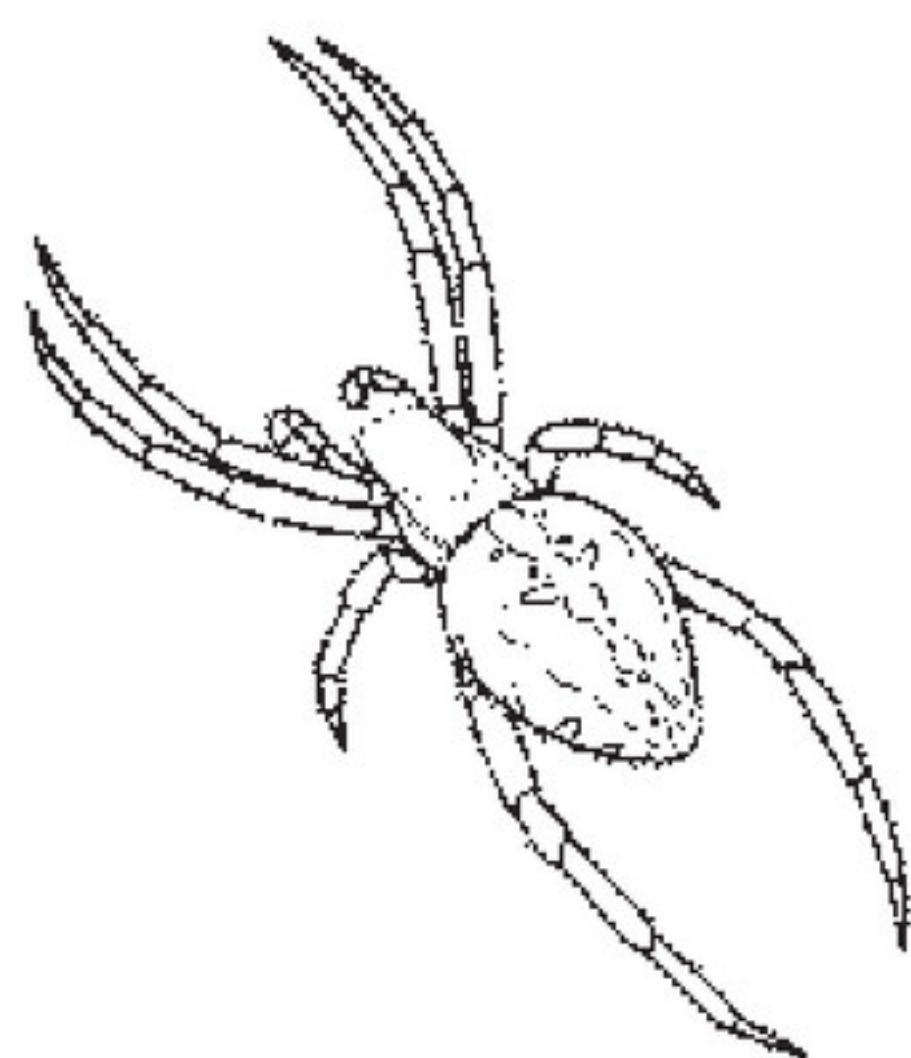








A large empty rectangular box for classification or notes.



A large empty rectangular box for classification or notes.

 Go to the *Flash cards*.

Learning how to do research

1

SCIENTIFIC RESEARCH

► Basics 4 | ► Learning objective 3.O.17

A lot of biologists do research. They do that at universities or in companies. Investigations where you start with a research question and often carry out experiments to find the answer are called **scientific research**. Scientific research consists of a number of steps.

THE STEPS IN RESEARCH

If you know what you want to investigate, you start by asking a question that you want to find the answer to. That is called the research question or **research question**. Sometimes you may already have an idea of what the answer might be. You then formulate a **hypothesis**: a possible answer to the research question. Using the research question and the hypothesis, you think up a work plan. A **work plan** describes how you want to carry out the research. The work plan should also have a list of the things you need for your investigation.

After you have made the work plan and collected what you need, you carry out the experiments, sticking as closely as possible to the work plan. When you carry out your research, you write down your observations and collect data. The observations and the data you record are the **results**. You can then use the results to draw a conclusion for your research. The **conclusion** answers your research question and lets you see if your hypothesis was correct.

Figure 1 shows an example of scientific research.

fig. 1

The steps in scientific research.

1 The research question: what do I want to investigate?

You have just bought a packet of seeds. You notice that the seeds in the packet are not germinating. So you ask yourself, *Why don't the seeds in a sachet start germinating?*

Er... maybe because they aren't getting any air?



Why don't the seeds in a packet start germinating?



2 The hypothesis: what do I think the answer might be?

You might think that the seeds need air if they are going to germinate. You then formulate the following hypothesis: *Seeds in a packet don't germinate because they aren't getting enough fresh air.*

3 The work plan: what am I going to do and what do I need?

To investigate whether the lack of air is the reason why the seeds aren't germinating, you can prick holes in a packet with a pin. After a couple of days, that packet can be compared with one that did not have any holes pricked in it. You can write down your work plan as follows:

Requirements:

- 2 identical packets of the same type of seed
- a pin

I will take two packets of the same kind of seeds. I will prick holes in one packet so that air can get into it. I will not do this for the other one. After a few days, I will look inside both packets and see how many of the seeds have germinated. I will write the numbers down in a table.



4 Doing the experiment

You gather together the things you need and you do the experiment according to your work plan.

5 The results: what are my observations?

You examine the results you got when you carried out the experiment. Your table looks like this:

	Number of germinated seeds
Packet with holes	0
Packet without holes	0

You describe what the table shows you: *There is no difference between the seeds in the two packets. The seeds have not germinated in either of them.*



6 The conclusion: what conclusion can be drawn?

You use the results to draw the following conclusion: *Seeds in a sachet do not fail to germinate because they are not getting enough fresh air.*

2

TYPES OF RESEARCH

► Basics 4 | ► Learning objective 3.O.18

When a hypothesis is drawn up in a study, the researcher can do an experiment to see if the hypothesis is correct. This is called **experimental research**.

Many scientific studies have a hypothesis, but that isn't always the case. For example, a researcher might want to know what the eating habits are of children aged between 6 and 10. No hypothesis is needed for this research because you cannot test it with an experiment. In this case, the researcher observes the eating habits of the children and describes the observations. This type of study is called **descriptive research**.

A researcher sometimes wants to know what other people have written about a subject. They read and compare various articles and other sources to discover new facts. The researcher who wants to know about children's eating habits could read scientific articles about children in various countries. That would let them discover similarities and differences. This type of research is called a **literature study** or literature review. Literature reviews do not always need a hypothesis either.

EXERCISE

1

Read the text about "The National Garden Bird Census".

- a What type of research is the National Garden Bird Census: experimental research, descriptive research or a literature study? Explain your answer.
- b As well as the National Garden Bird Census, there has also been a National Bee Census since 2018. There are nearly 360 species of wild bees in the Netherlands but half those species are threatened.
Lucy wants to investigate whether there is a link between the bee species that are under threat and the fact that certain plants are disappearing in the Netherlands. She does this by reading various reference works about the threatened bee species. She also reads articles about the vegetation in the Netherlands (the plants that grow here) over the last hundred years.
What type of research is this: experimental research, descriptive research or a literature study? Explain your answer.
- c Bees are important for pollinating flowering plants. They are mostly attracted by the colours and scents of the flowers.
Sam wants to know if bees are more sensitive to the colour of a flower or its scent. He thinks that bees are attracted more by the scent. He thinks up an experiment with honey bees and paper flowers that can have the colour or the smell of the real flowers.
What type of research is Sam doing: experimental research, descriptive research or a literature study? Explain your answer.

fig. 2

The National Garden Bird Census

Gardens are important places for birds to survive the winter. To study this, the National Garden Bird Census is held every year in the last weekend of January. All Dutch people are asked to count all the birds in their garden for half an hour. There is a form to help you do that on the Internet (www.tuinvogeltelling.nl). After the count, the results can be entered on the site. That is how data is collected for this research.

3

CARRYING OUT RESEARCH AND DRAWING THE CONCLUSION

► Basics 5 | ► Learning objectives 3.O.19 and 3.O.20 | ► Practical activities 6 and 7

RESEARCH

When you are doing research, you work according to a work plan that was made in advance. You follow that work plan step by step. You record the results clearly, for instance in a table or as a graph. Then you summarise the results. You do that by describing your observations briefly or summarising them. For instance, the seeds in packet 1 germinated after one day and the seeds in packet 2 germinated after three days.

DRAWING A CONCLUSION

You can then use the results to draw a conclusion for your research. You will generally only have a single conclusion, but sometimes two or more conclusions can be drawn. You use the conclusion to answer your research question. You also say whether your hypothesis was correct or not. Only the results of the investigation are used for drawing the conclusion: you mustn't use any information from other sources. You must not look at other people's results either.

Sometimes your results may be different from the results in other research. For example, a researcher who is trying to find a link between children drinking fizzy drinks and being overweight may get research results that don't show a relationship, whereas other researchers have different results that do show a link. The first researcher still has to draw the conclusion that they did not find any link.

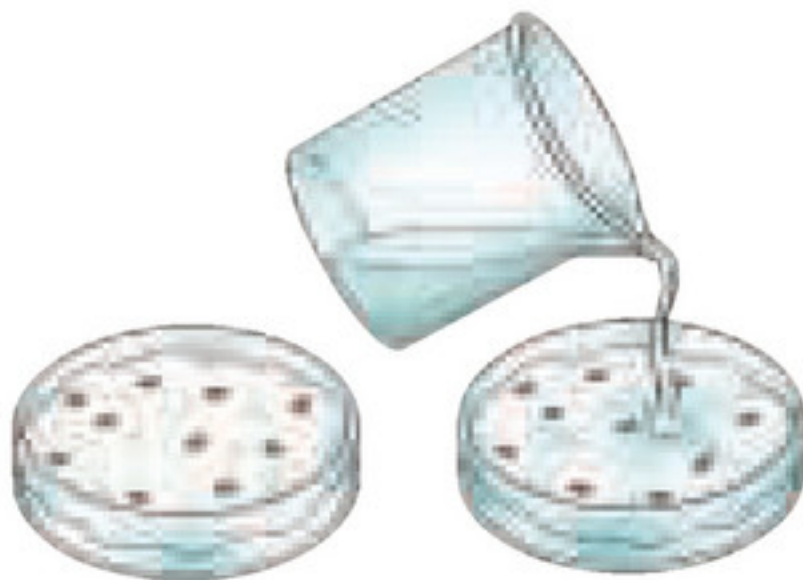
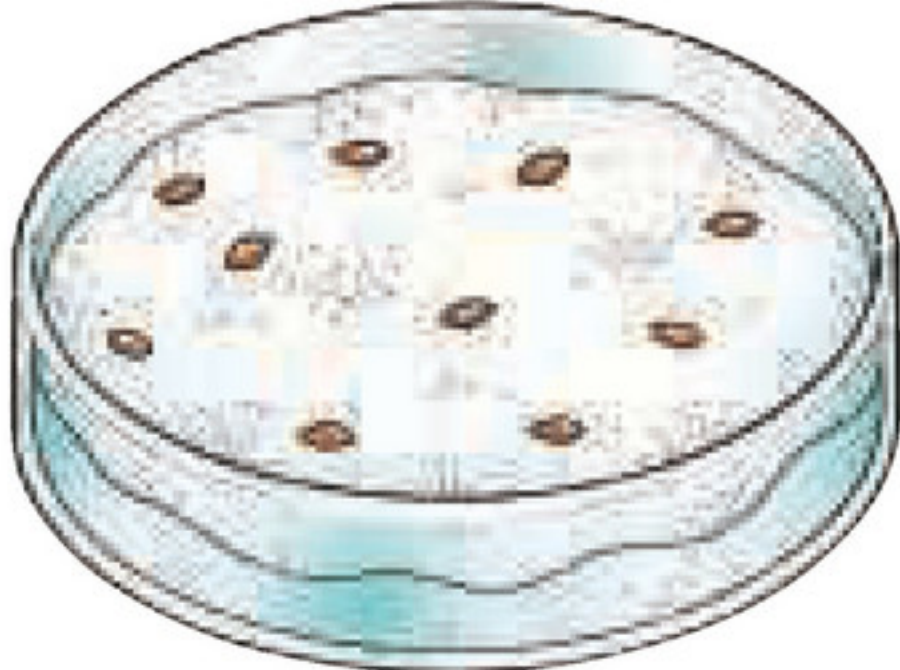
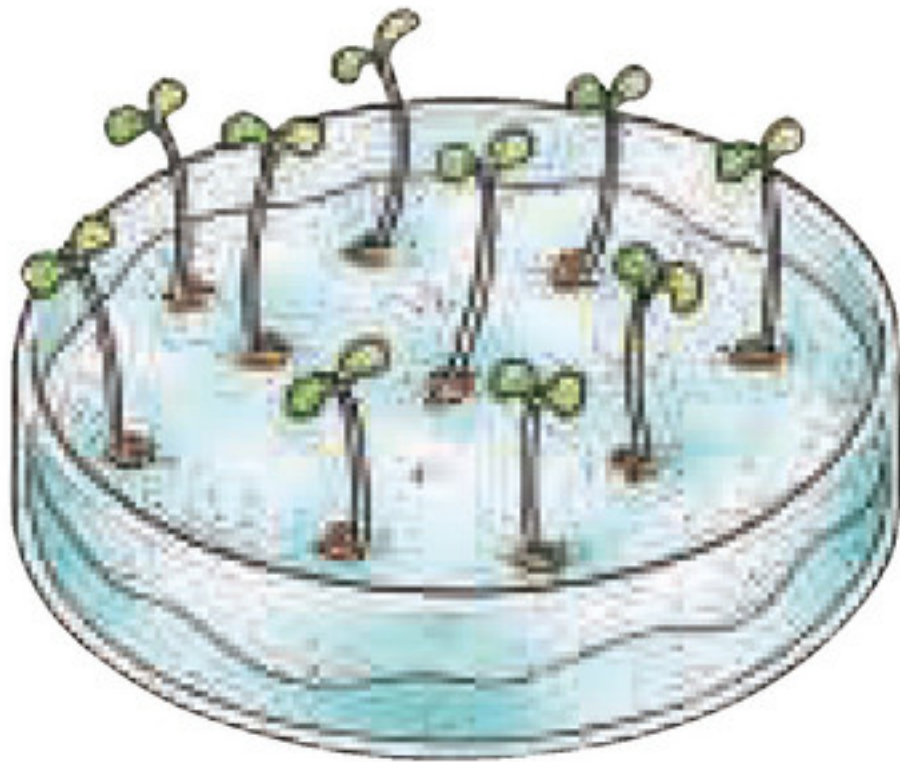
EXERCISES

2

Tim has bought a packet of tomato seeds. He wonders why the seeds in the packet are not germinating. To investigate this, he does an experiment. Figure 3 shows this research in a table. Nothing has been written down for the conclusion yet.

- a** Why does Tim put ten seeds on each dish and not just one?
- b** Why do the seeds on both dishes have to get the same amount of light, air and heat?
- c** What can you say about the germination of tomato seeds, looking at the results?
- d** Write the conclusion down in the table. Phrase the conclusion so that it answers the research question.

fig. 3

RESEARCH	THE EFFECT OF WATER ON SEED GERMINATION
Research question	Why don't the tomato seeds in a packet start germinating?
Hypothesis	Tomato seeds in a packet do not germinate because they are not getting any water.
What do you need?	☐ 2 Petri dishes ☐ 20 tomato seeds ☐ cotton wool ☐ glass beaker ☐ water
Work plan	 I will take two Petri dishes. I will put a layer of cotton wool in both dishes.  I will scatter ten tomato seeds around on each of the dishes, spreading the seeds around evenly in the dish.  I will put a small amount of water into one of the Petri dishes. I will make sure that both dishes get the same amount of light, air and heat. After three days, I will look to see what has happened.
Results	After three days without water:  After three days with water: 
Conclusion	

3

House plants grow better if you add a little bit of indoor plant fertiliser to their water occasionally (for example Pokon or Substral).

Daniela thinks that cress seedlings will grow more quickly too if houseplant fertiliser is added to the water. She carries out a study to find out if her idea is right. Figure 4 shows this research in a table. The conclusion of the study has not been filled in.

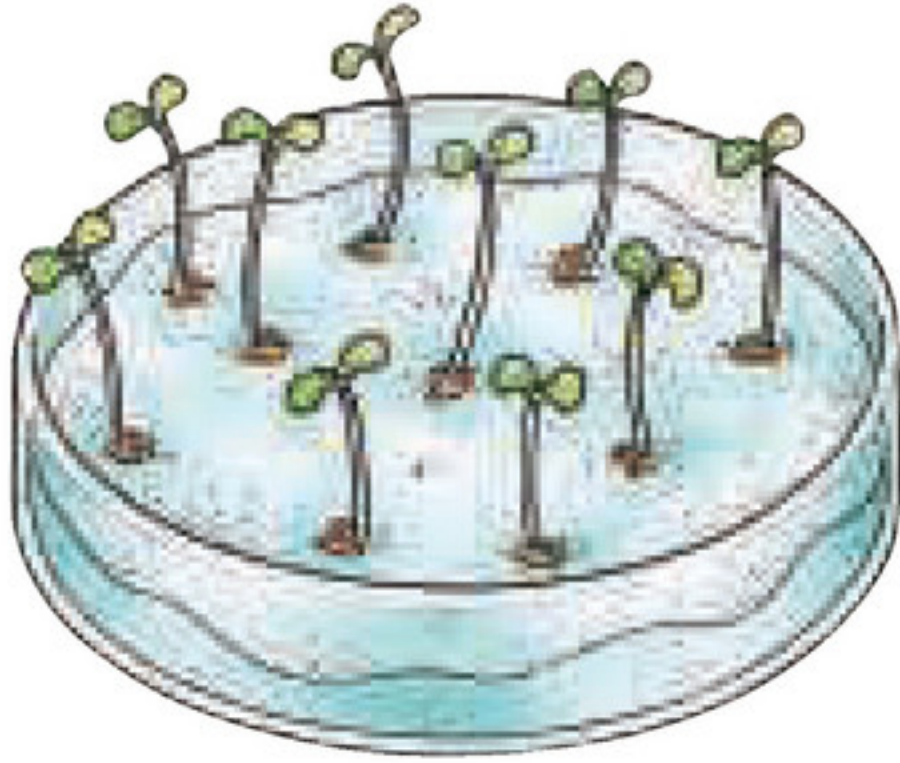
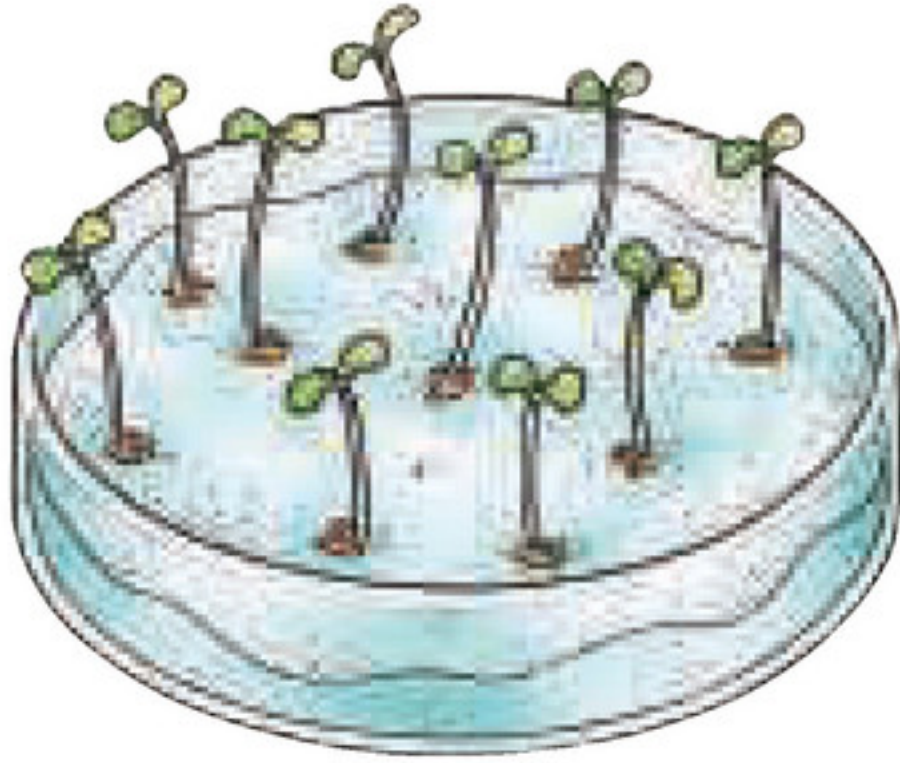
a What can you say about the heights of the seedlings, looking at the results?

b Write down the conclusion of this research in the table.

c What might be an explanation for this conclusion?

fig. 4

RESEARCH	EFFECT OF HOUSEPLANT FERTILISER ON THE GROWTH OF CRESS SEEDS
Research question	What effect does houseplant fertiliser have on the growth of cress seedlings?
Hypothesis	If you add houseplant fertiliser to the water, the cress seedlings will grow better.
What do you need?	☐ 2 Petri dishes ☐ cotton wool ☐ fertiliser for indoor plants ☐ 20 cress seeds ☐ a glass beaker of water
Work plan	Without houseplant fertiliser:  With houseplant fertiliser:  I will take two Petri dishes. I will put a layer of cotton wool in both Petri dishes. I will add a layer of water to one of the dishes. I will add the same amount of water to the other dish, but this time with houseplant fertiliser (as stated in the instructions for use on the packaging). I will put ten cress seeds on the wet cotton wool in each dish. I will make sure that both dishes get the same amount of light, air, moisture and heat. After three days, I will measure how tall the cress seedlings are.

Results	Without indoor plant fertiliser, after three days:  average height of the plants: 1.7 cm With indoor plant fertiliser, after three days:  average height of the plants: 1.7 cm
Conclusion	

4

IDENTIFICATION

► Basics 6 | ► Learning objective 3.O.21

Organisms that you do not know can still be classified into a kingdom or phylum or class by looking at their characteristics. This is called **identification**. As an example, look at a white deadnettle (see figure 5). You can classify this organism using an identification table (see figure 6).

fig. 5 Cell features of the white deadnettle: cell wall, chloroplast.



fig. 6

IDENTIFICATION TABLE			
1	a	The organism has a cell wall around each cell.	continue from 2
	b	The organism does not have cell walls.	animals , continue from 3
2	a	The organism has chloroplasts.	plants , continue from 15
	b	The organism does not have chloroplasts.	fungi
3	a	The animal is symmetrical.	continue from 4
	b	The animal is asymmetrical.	sponges
4	a	The animal is radially symmetrical	continue from 5
	b	The animal is bilaterally symmetrical.	continue from 6
5	a	The animal has tentacles.	cnidarians
	b	The animal's skin is covered with spines or nodules.	echinoderms
6	a	The animal's skeleton is a shell.	molluscs
	b	The animal does not have a shell.	continue from 7
7	a	The animal has an exoskeleton (external skeleton, cuticle).	arthropods , continue from 8
	b	The animal has an internal skeleton with a spinal column	vertebrates , continue from 11
8	a	The animal has more than fifteen legs.	myriapods
	b	The animal has fewer than fifteen legs.	continue from 9
9	a	The animal has ten, twelve or fourteen legs.	crustaceans
	b	The animal has fewer than ten legs.	continue from 10
10	a	The animal has eight legs.	chelicerates
	b	The animal has six legs.	hexapods
11	a	The animal's skin is covered with scales	continue from 12
	b	The animal's skin is not covered with scales	continue from 13
12	a	The scales are covered in mucus	bony fish
	b	The scales are dry (not covered with mucus)	reptiles
13	a	The animal's skin is covered with mucus	amphibians
	b	The animal's skin is not covered with mucus	continue from 14
14	a	The animal's skin is covered with feathers.	birds (which belong with the reptiles)
	b	The skin of the animal is covered in hairs/fur.	mammals
15	a	The plant has vessels.	vascular plants , continue from 16
	b	The plant does not have vessels.	continue from 17
16	a	The plant has flowers and reproduces through seeds.	seed plants
	b	The plant does not have flowers and reproduces through spores.	cryptogams (spore-bearing plants)
17	a	The plant has leaves, stems and (mostly) roots.	mosses (three phyla)
	b	The plant does not have leaves, stems and roots.	algae (four phyla)

If you want to identify an organism, start at number 1. Next to number 1 in the identification table, you see:

- | | | | |
|---|---|--|----------------------------------|
| 1 | a | The organism has a cell wall around each cell. | continue from 2 |
| | b | The organism does not have cell walls. | animals , continue from 3 |

The white deadnettle has a cell wall around every cell, so you have to continue from 2. There are two possibilities there:

- | | | | |
|---|---|--|----------------------------------|
| 2 | a | The organism has chloroplasts. | plants , continue from 15 |
| | b | The organism does not have chloroplasts. | fungi |

The white deadnettle does have chloroplasts, so it is a **plant**. Now you have to continue from 15. There are two possibilities there once again:

- 15 a

The plant has vessels.

15 b

The plant does not have vessels.
- vascular plants

, continue from 16

continue from 17

The white deadnettle does have vessels so it is a vascular plant. Continue from 16. There are two possibilities there as follows:

- 16 a

The plant has flowers and reproduces through seeds.

16 b

The plant does not have flowers and reproduces through spores.
- seed plants

cryptogams

(spore-bearing plants)

The white deadnettle has flowers and reproduces through seeds, so it is a **seed plant**.

A white deadnettle is therefore a member of the **plant kingdom** and the phylum of **vascular plants**. Because it has flowers, you also know that it is a **seed plant**. You should also note down the steps that you take as you go through the identification table. For the white deadnettle, it was **1a – 2a – 15a – 16a**.

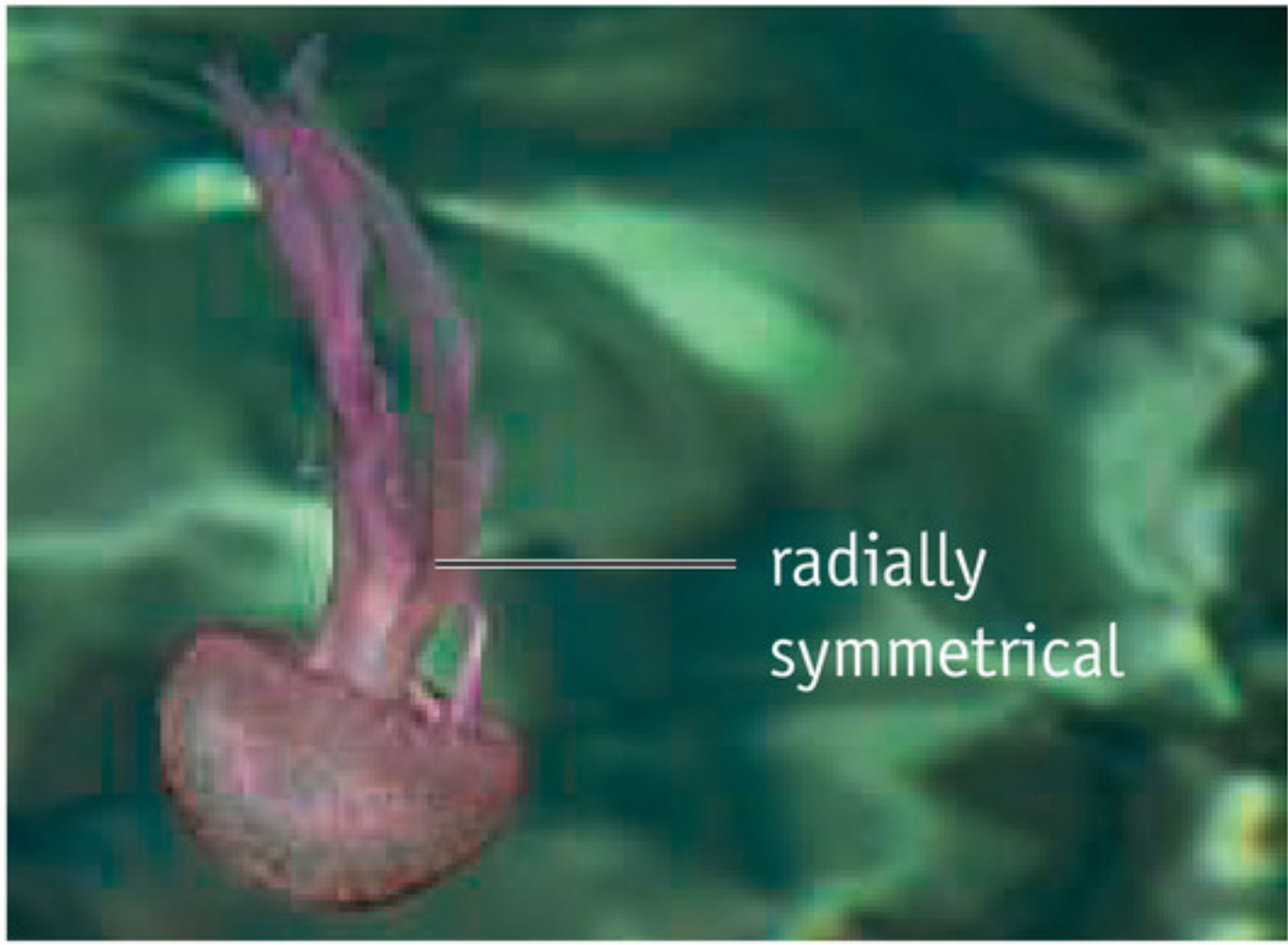
EXERCISE

4

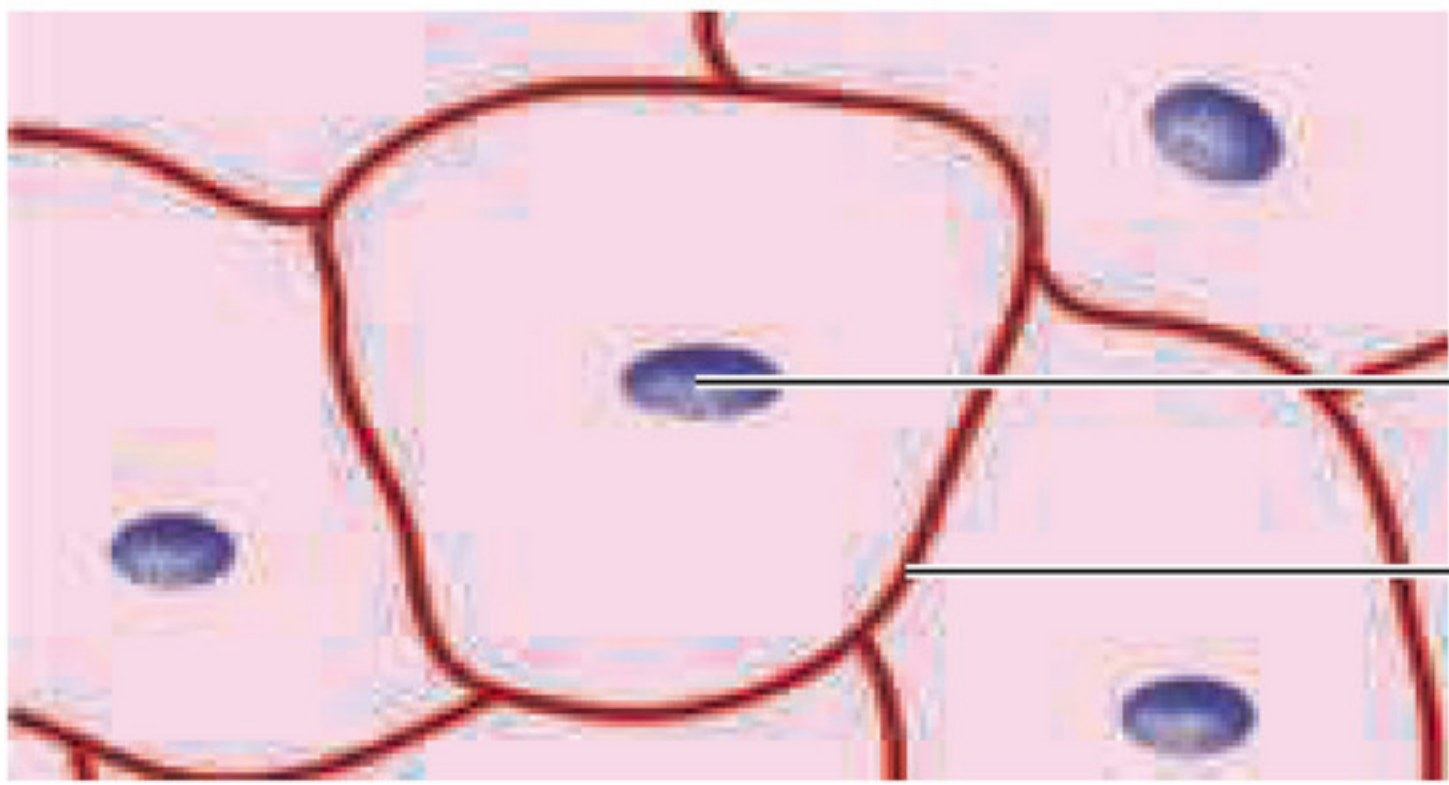
- There are eight multicellular organisms in figure 7.
- Classify these organisms using the identification table in figure 6. (Take another look at figure 6 in Basics 3 if it will help.)
 - Complete the table. In the ‘steps’ column, you write down the numbers and letters for each step that you take through the identification table.

Animal	Belongs to	Steps
Purple striped jellyfish	kingdom: phylum:	
Porcini	kingdom:	
Stick insect	kingdom: phylum: subphylum:	
Sea cucumber	kingdom: phylum:	
Dandelion	kingdom: phylum: subphylum:	
Fire salamander (a newt)	kingdom: phylum: class:	
Wall screw-moss	kingdom: phylum:	
Seahorse	kingdom: phylum: class:	

fig. 7



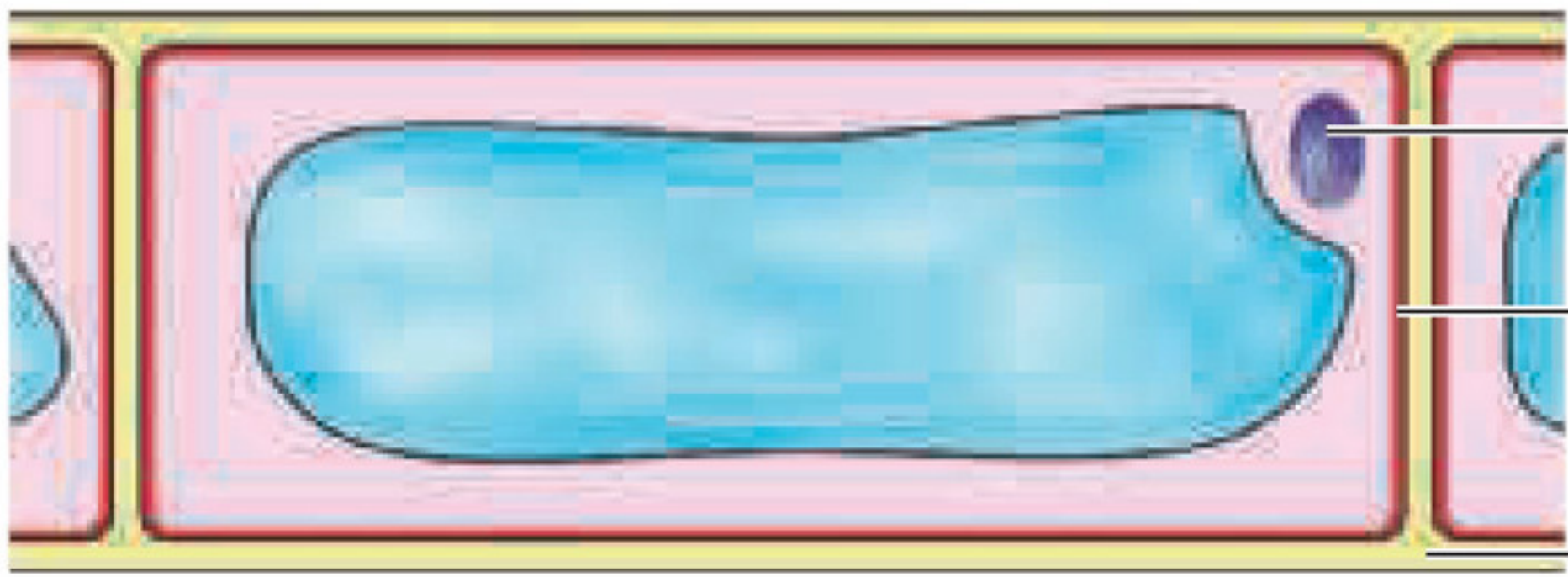
1 purple striped jellyfish



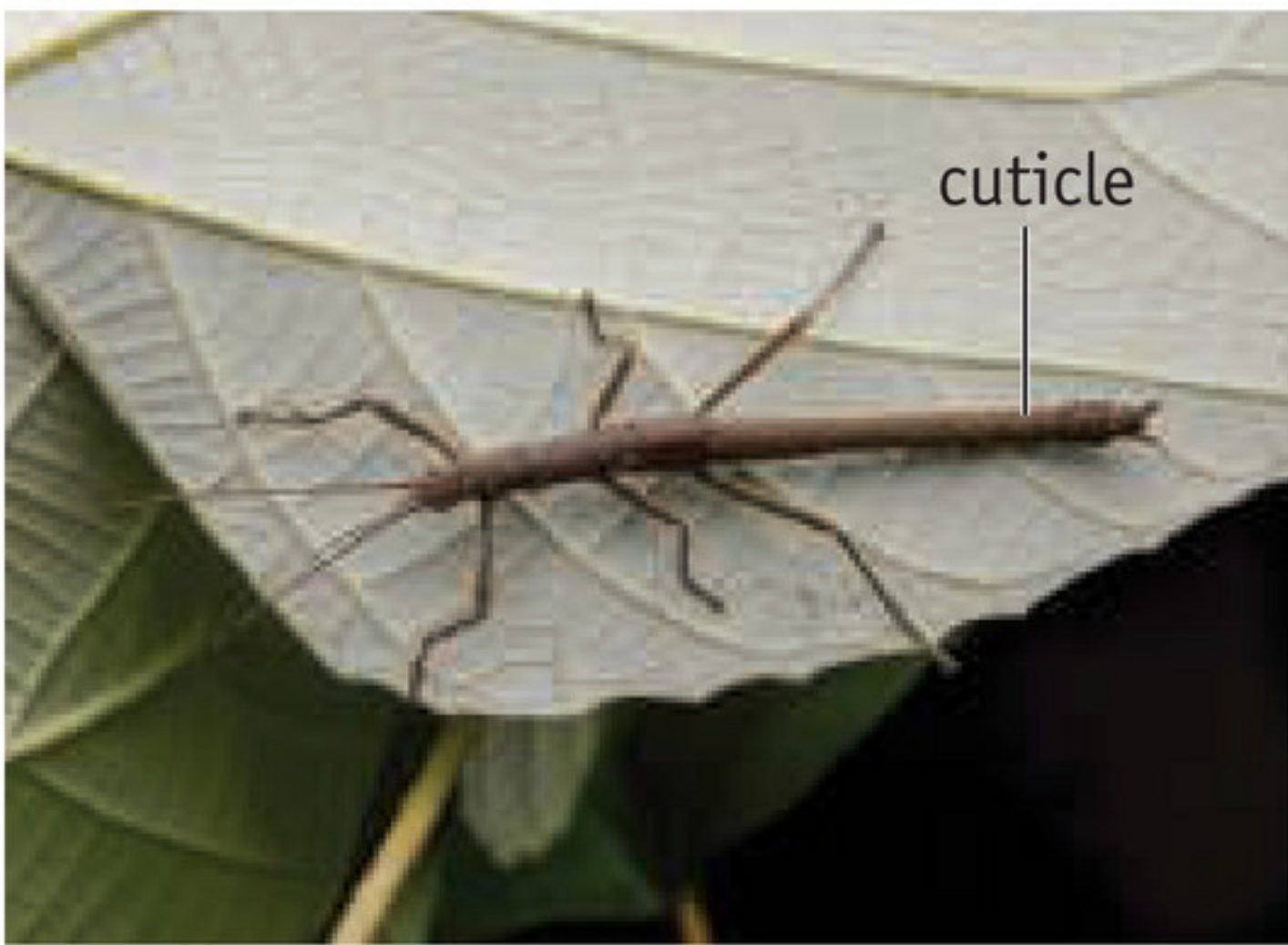
nucleus
cell membrane



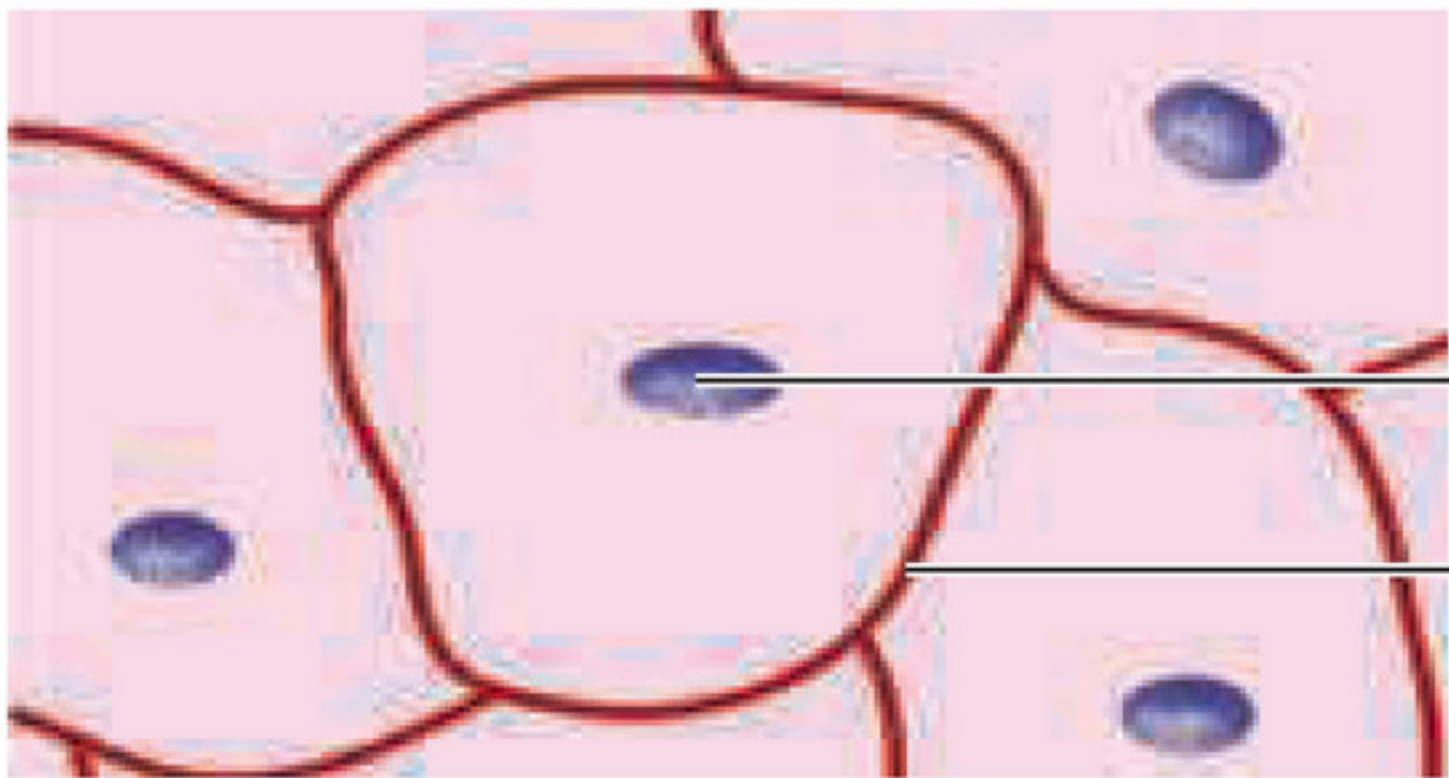
2 porcini



nucleus
cell membrane
cell wall



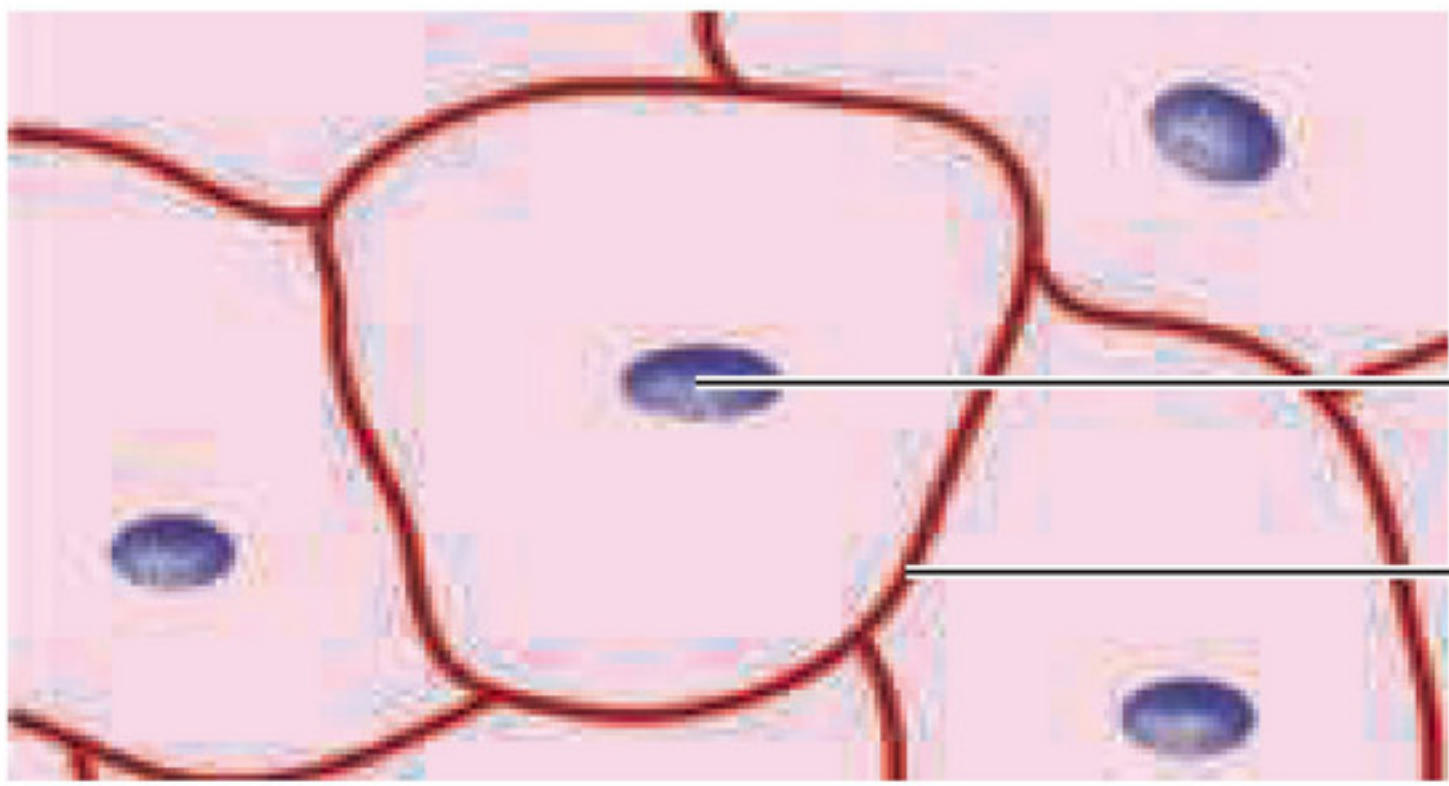
3 stick insect



nucleus
cell membrane



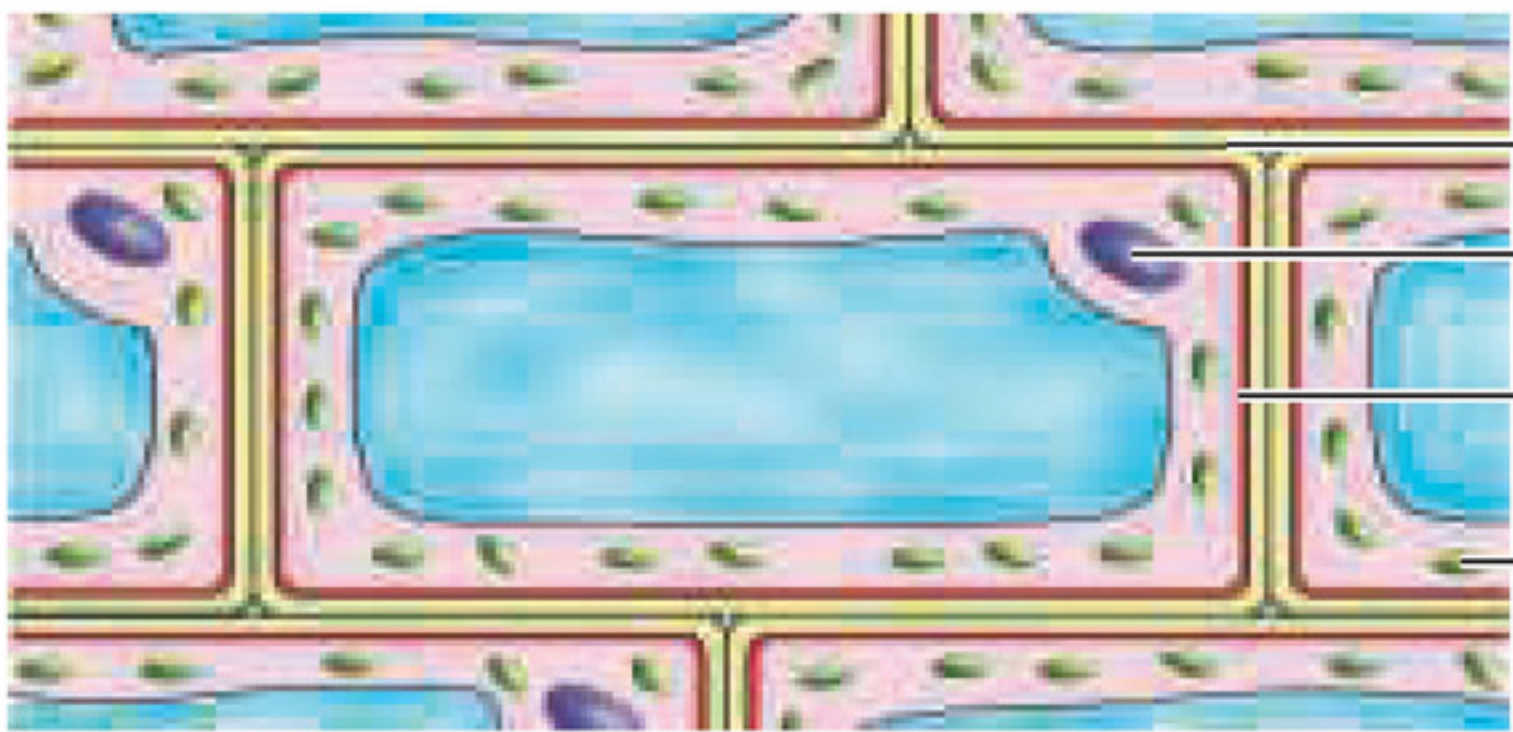
4 sea cucumber



nucleus
cell membrane



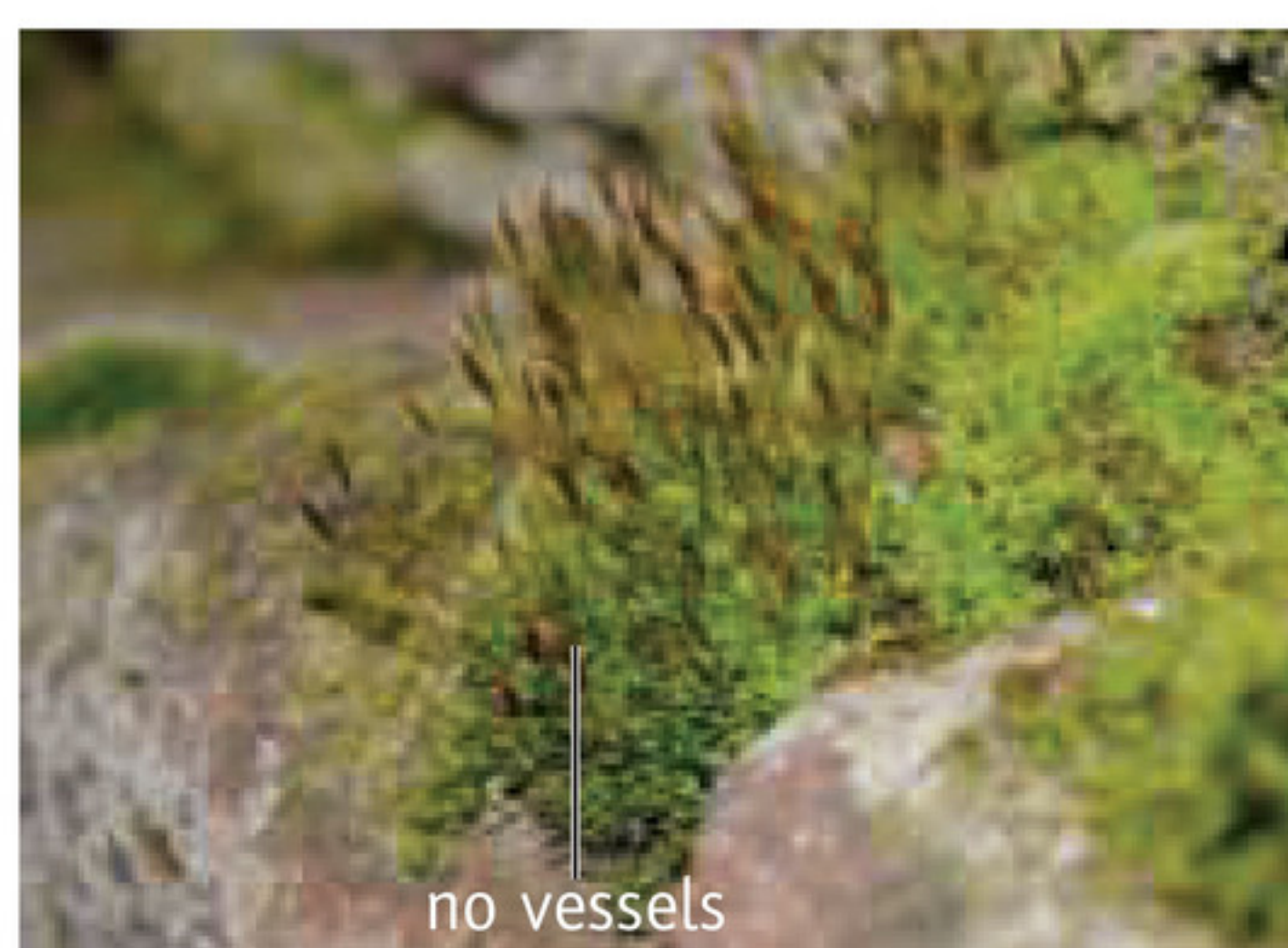
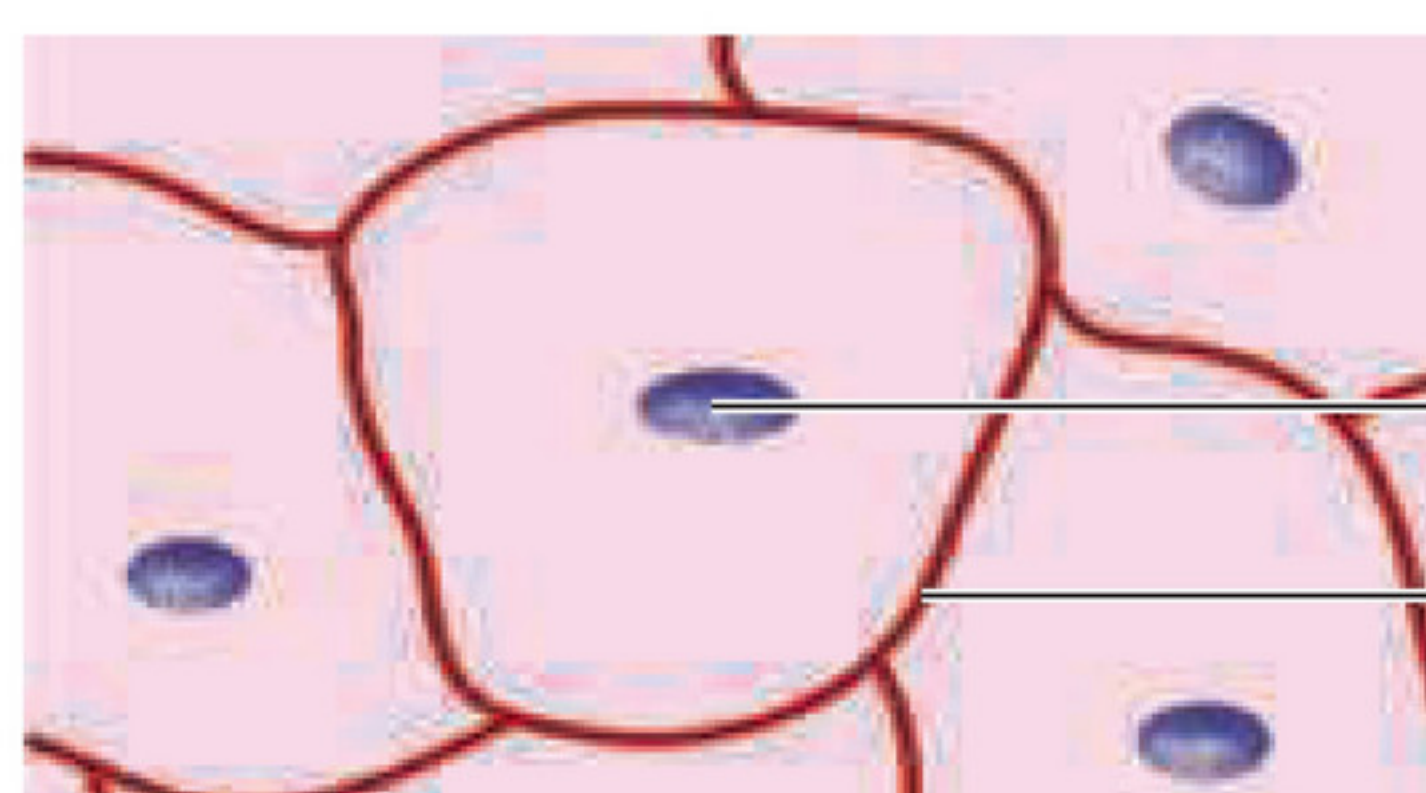
5 dandelion



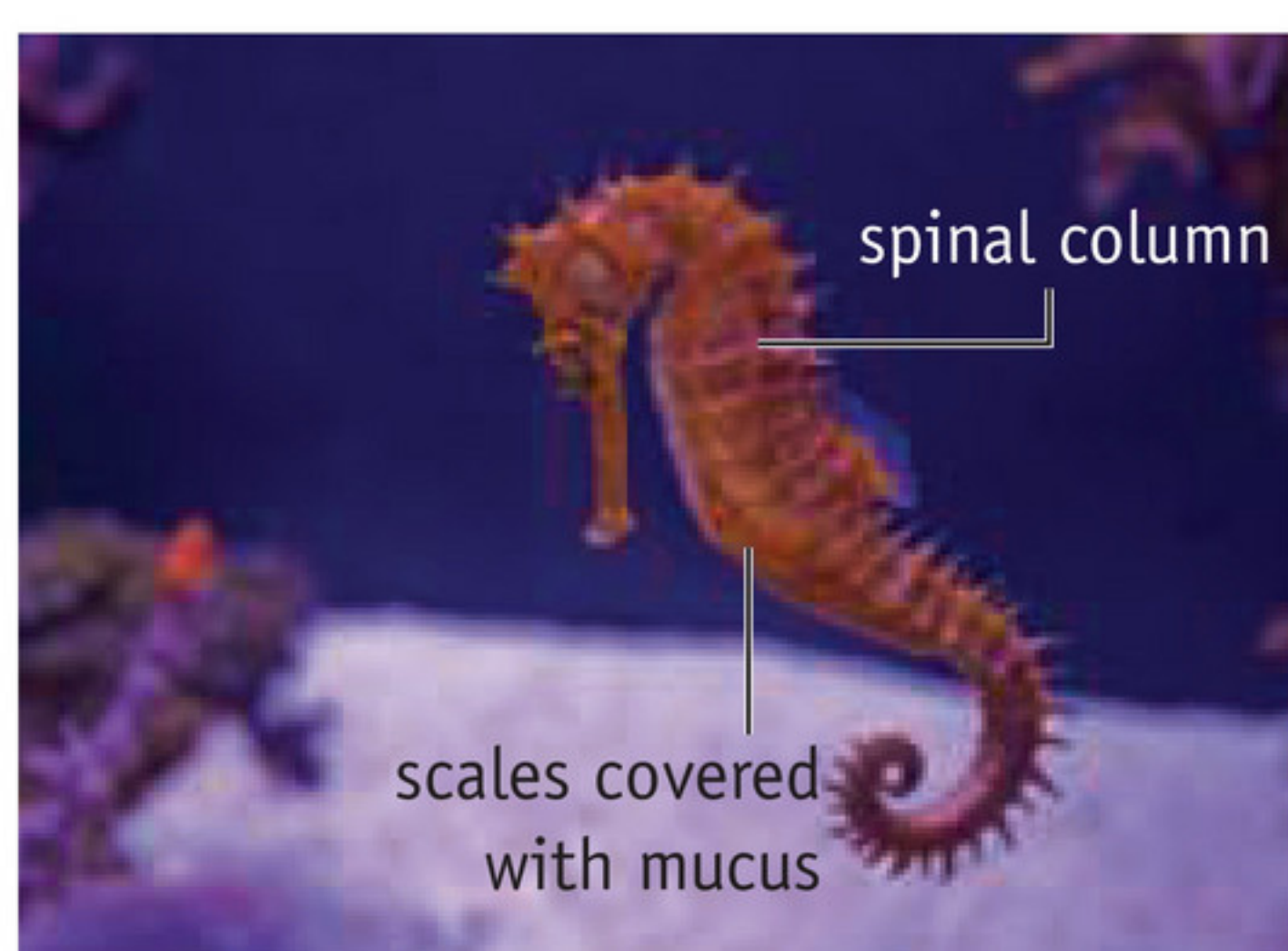
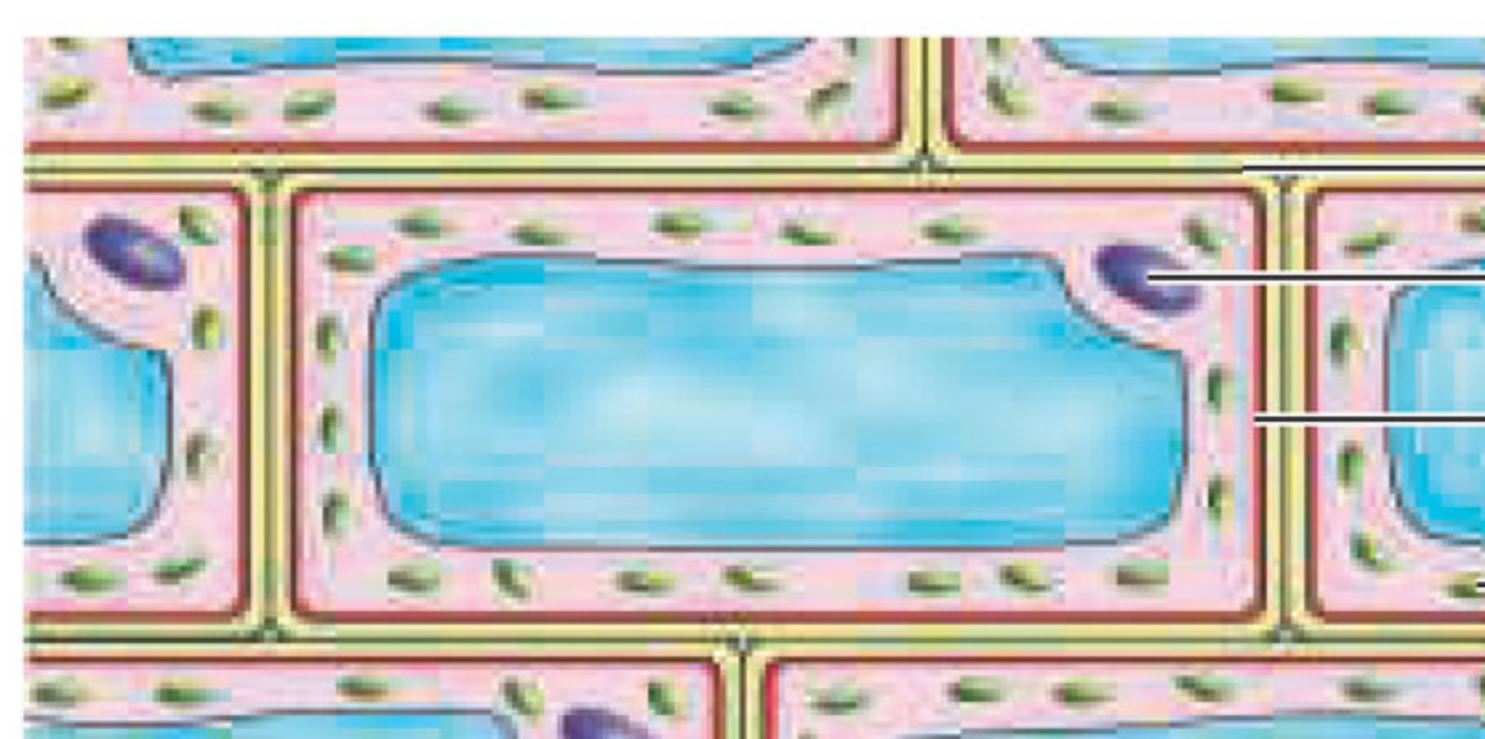
cell wall
nucleus
cell membrane
chloroplast



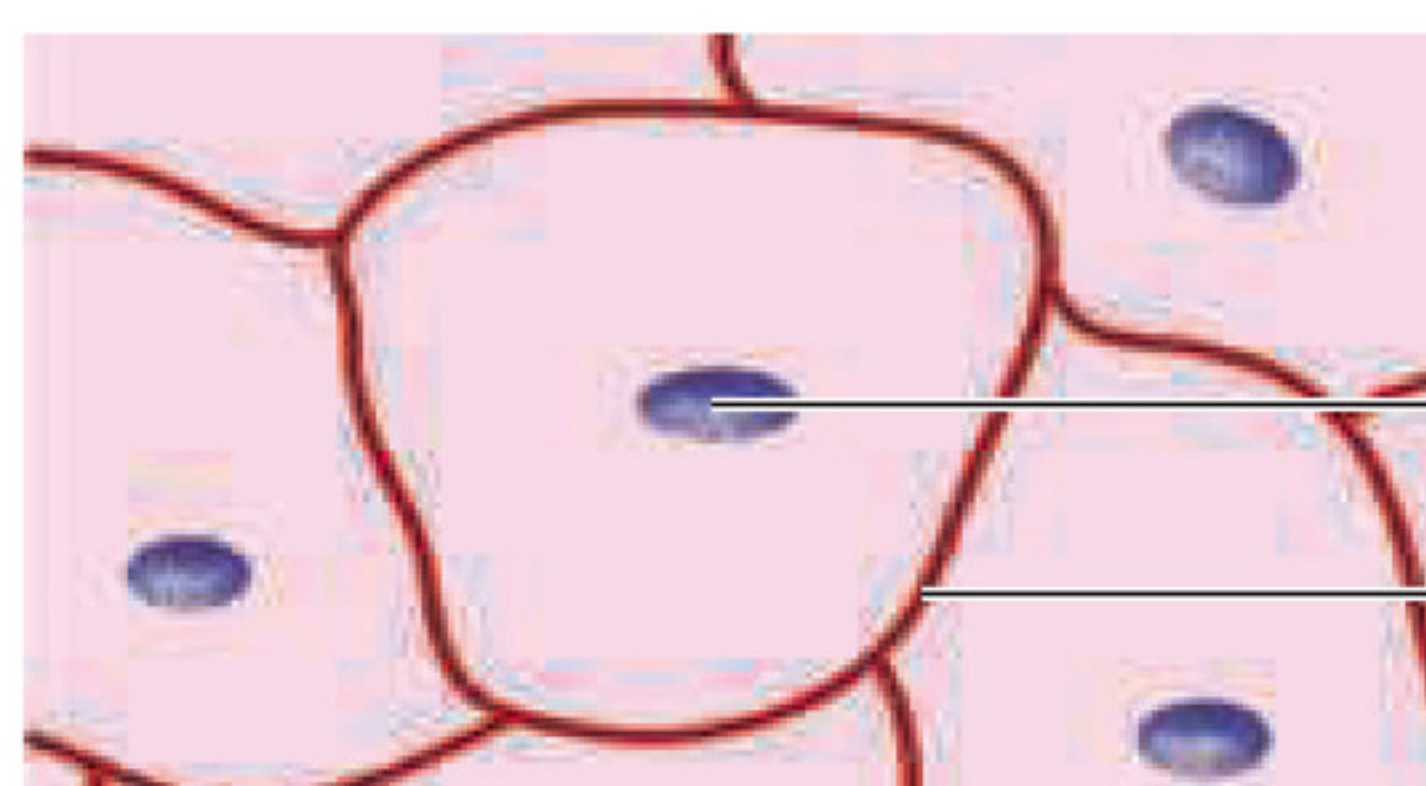
6 fire salamander



7 wall screw-moss



8 seahorse



5

Read the text about “Ladybirds”. This is part of a booklet about ladybirds.

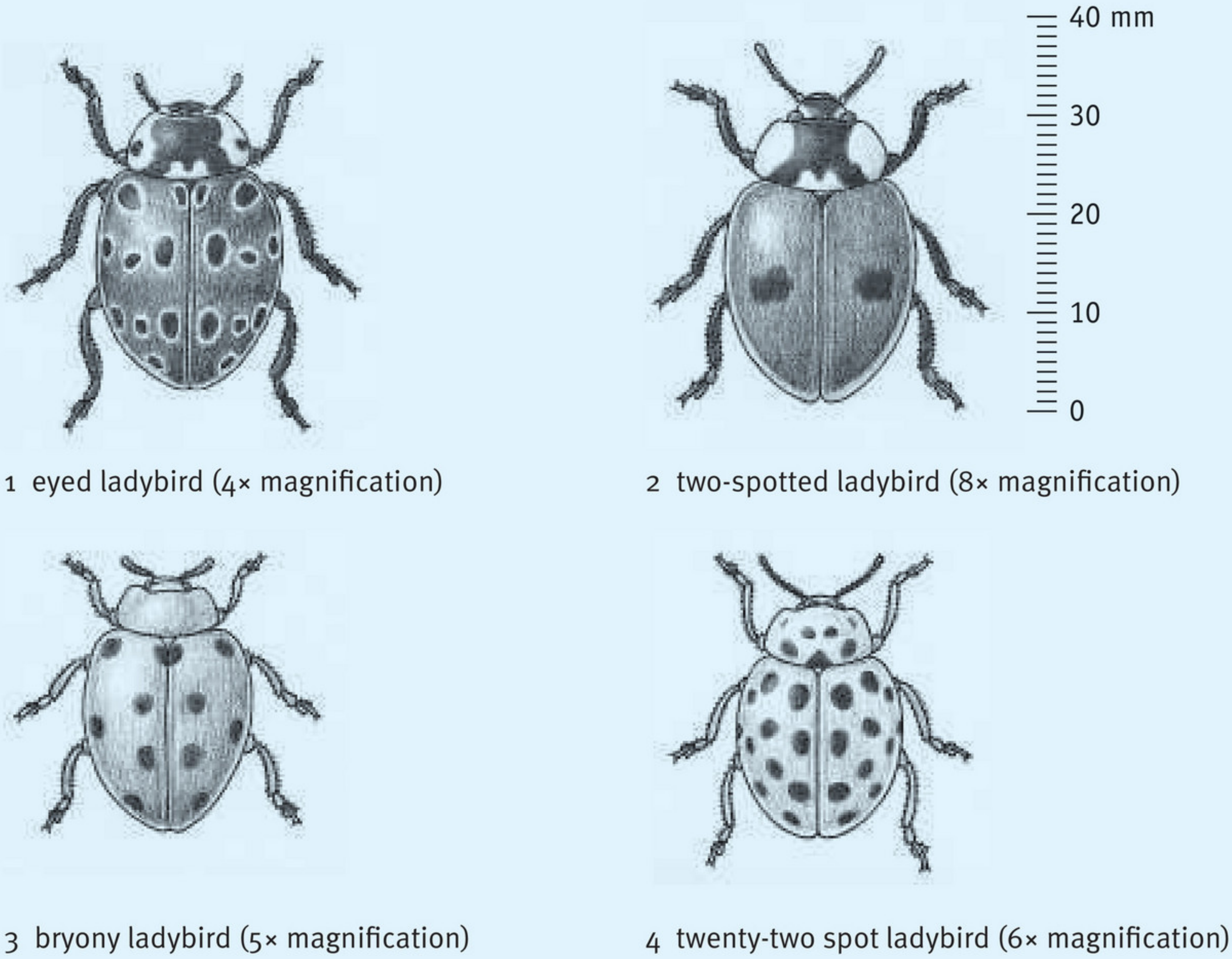
- a** Work out how big a two-spotted ladybird is in reality (without the legs and the antennae on its head).
- b** The number of spots is a feature that lets you identify the ladybird species. That gives you four groups. The table lists another feature that you can use to classify these four species further into two groups.
Which characteristic is that? Explain your answer.
- c** What other feature (apart from the number of spots) can you use to tell eyed ladybirds from two-spotted ladybirds? Explain your answer.

fig. 8

Ladybirds

There are about sixty species of ladybirds that live in the Netherlands. To identify them, you use the features (characteristics) of the various species. Drawings and features of four species of ladybird are shown here.

Species of ladybird	Feeds on	Can be found in
Eyed ladybird	many aphid species, mostly on conifers	widespread, throughout the Netherlands, sometimes numerous near beaches
Two-spotted ladybird	many aphid species, mostly on deciduous trees	very widespread, throughout the Netherlands
Bryony ladybird	leaves	used to be only in Limburg, now in various places
Twenty-two spot ladybird	mildew (moulds) on oak trees, dogwood and peas; also on blooming mullein, hops, wormwood and old man’s beard	fairly widespread, throughout the Netherlands



Practical activities

1

THE MUSSEL

► Basics 3 | ► Learning objective 3.3.7

 75-90 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you are going to cut open a mussel and examine it. You will cut the mussel open using a sharp knife. You will make drawings.

WHAT DO YOU NEED?

- ☐ a saltwater mussel that has been cooked (just for a moment) in a dish
- ☐ a scalpel (see figure 1) or a knife
- ☐ scissors
- ☐ drawing materials

fig. 1 Scalpel.



WORKING METHOD

- Put the mussel down in front of you. The mussel is covered by two shells that fit tightly together. You can see growth bands on the shells (see figure 2). The two shells are hinged together by the elastic ligament that holds the two shells in place (see figure 3).

fig. 2 Mussel (external view).

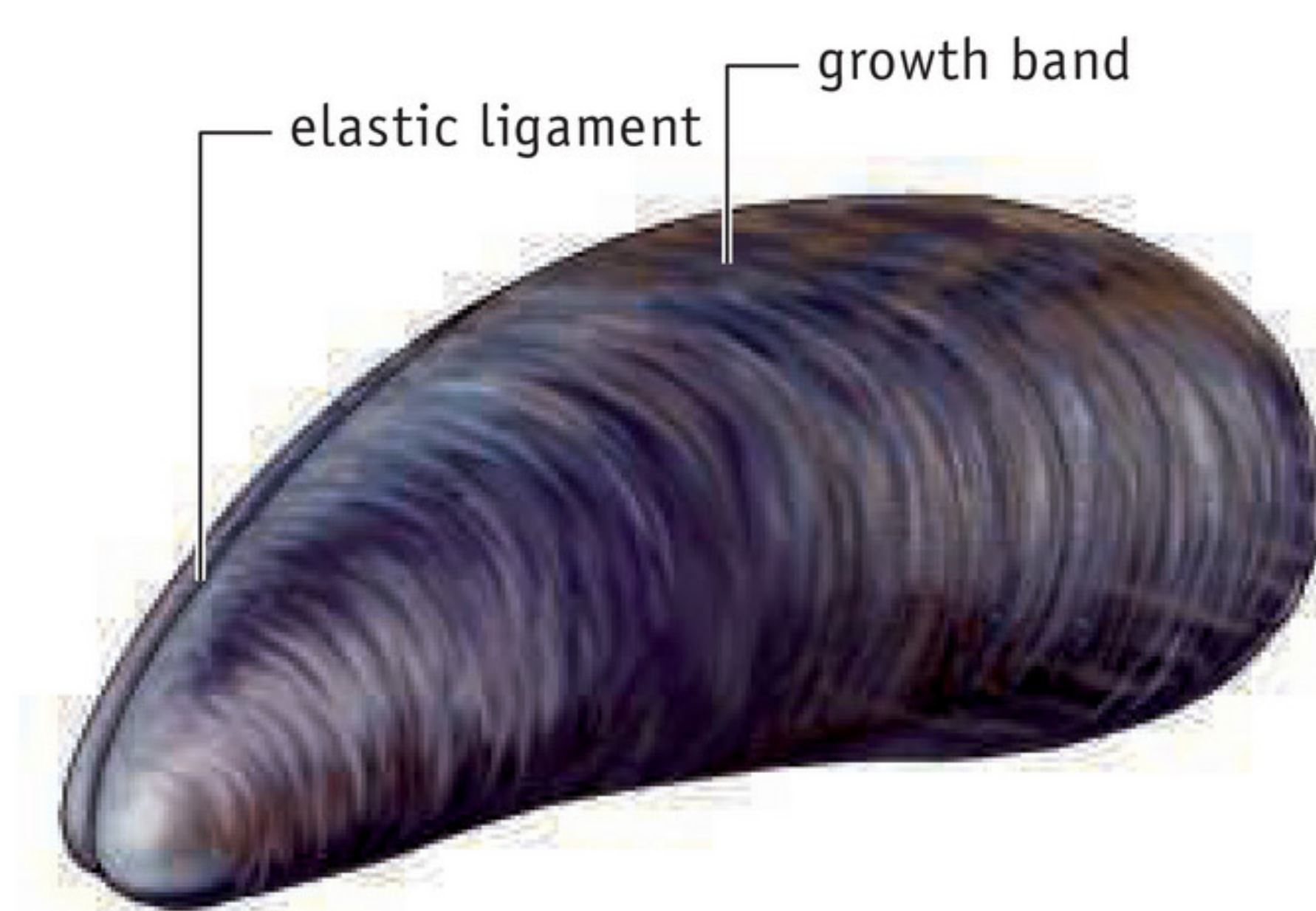
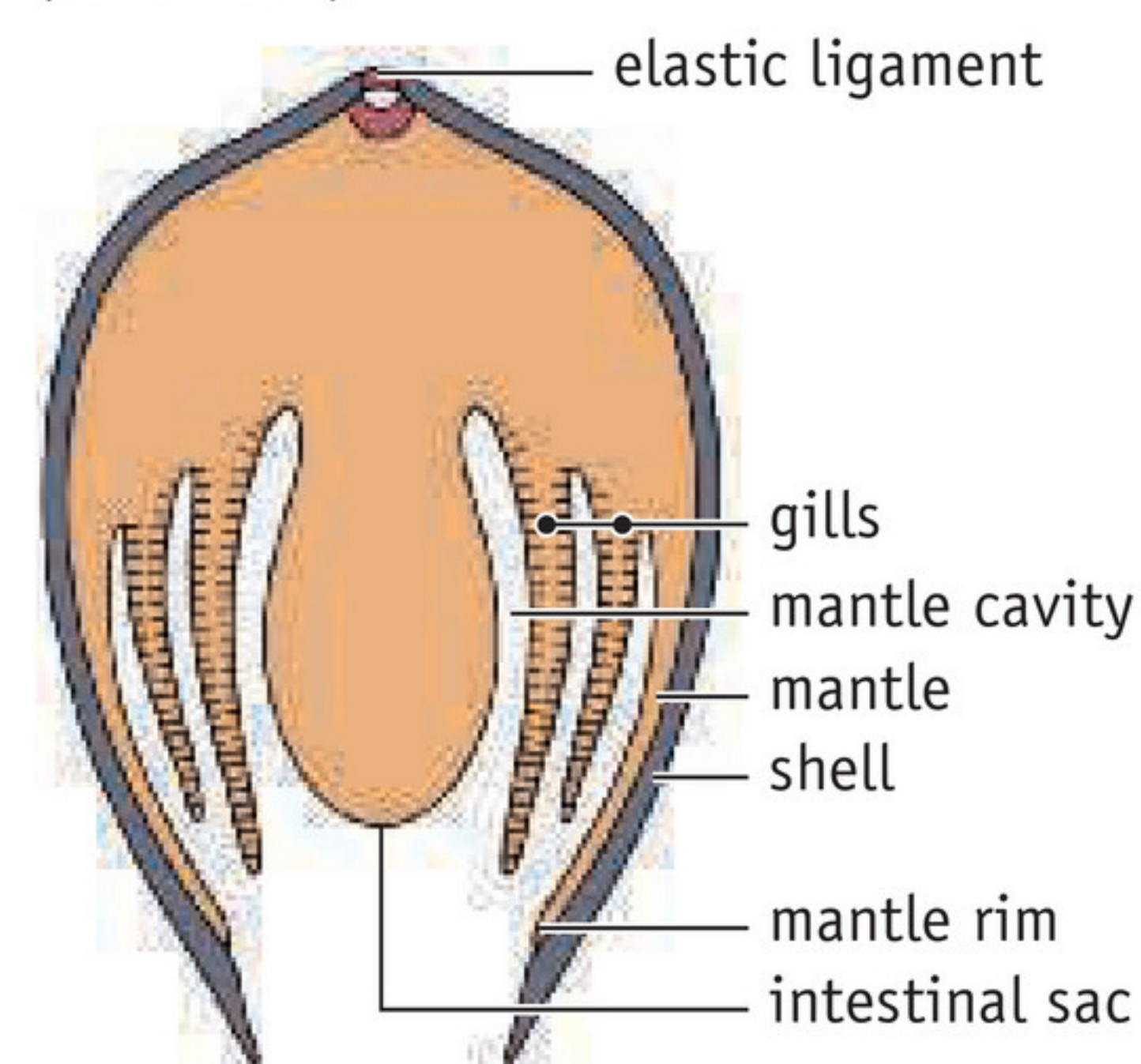
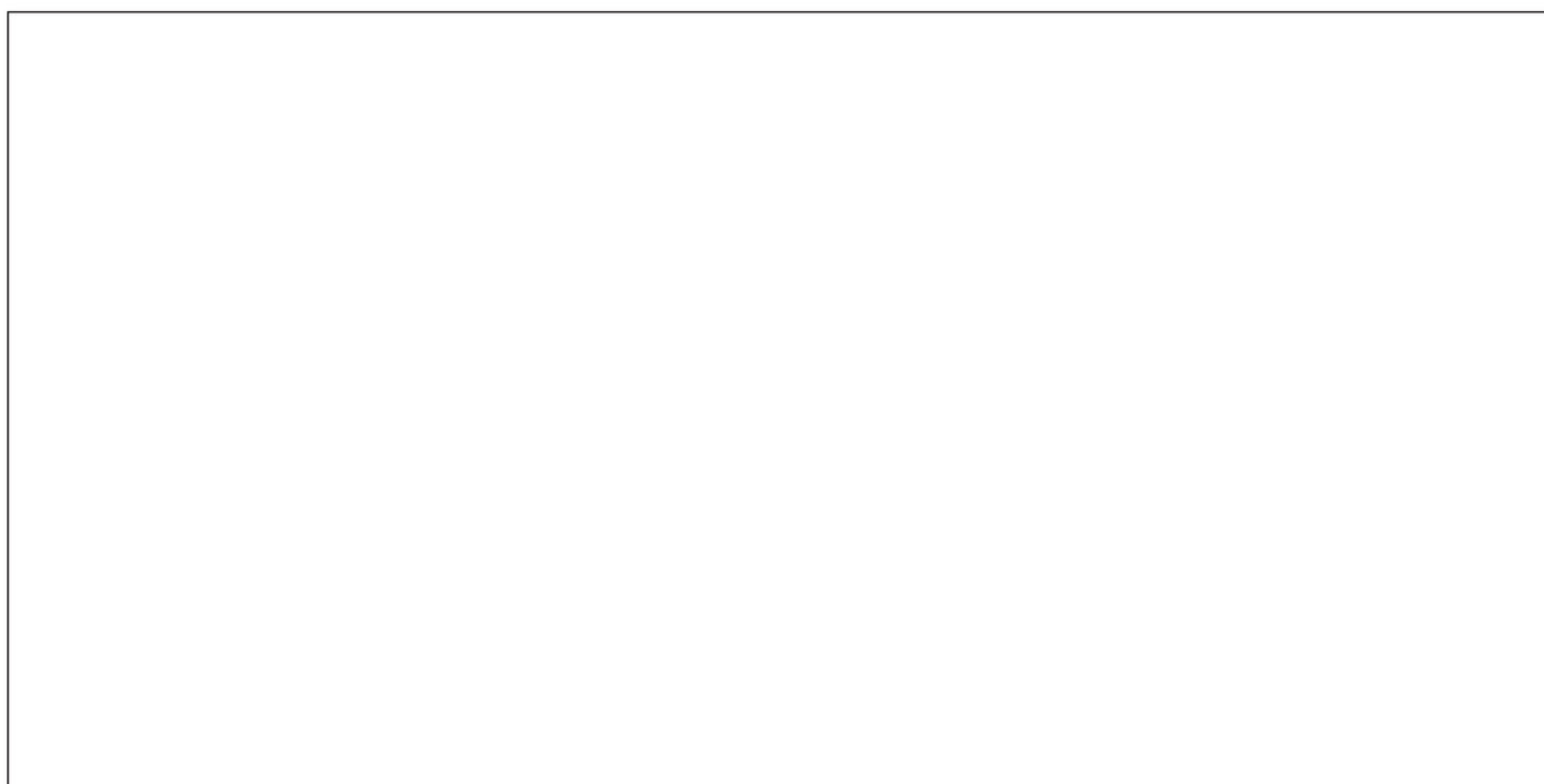


fig. 3 Cross-section of a mussel (schematic).



- Draw the external view of the mussel. Place the mussel so that you can see the elastic ligament and one of the shells. Draw accurately how the growth bands run across the shell. Label the following parts: *elastic ligament – growth band – shell*.

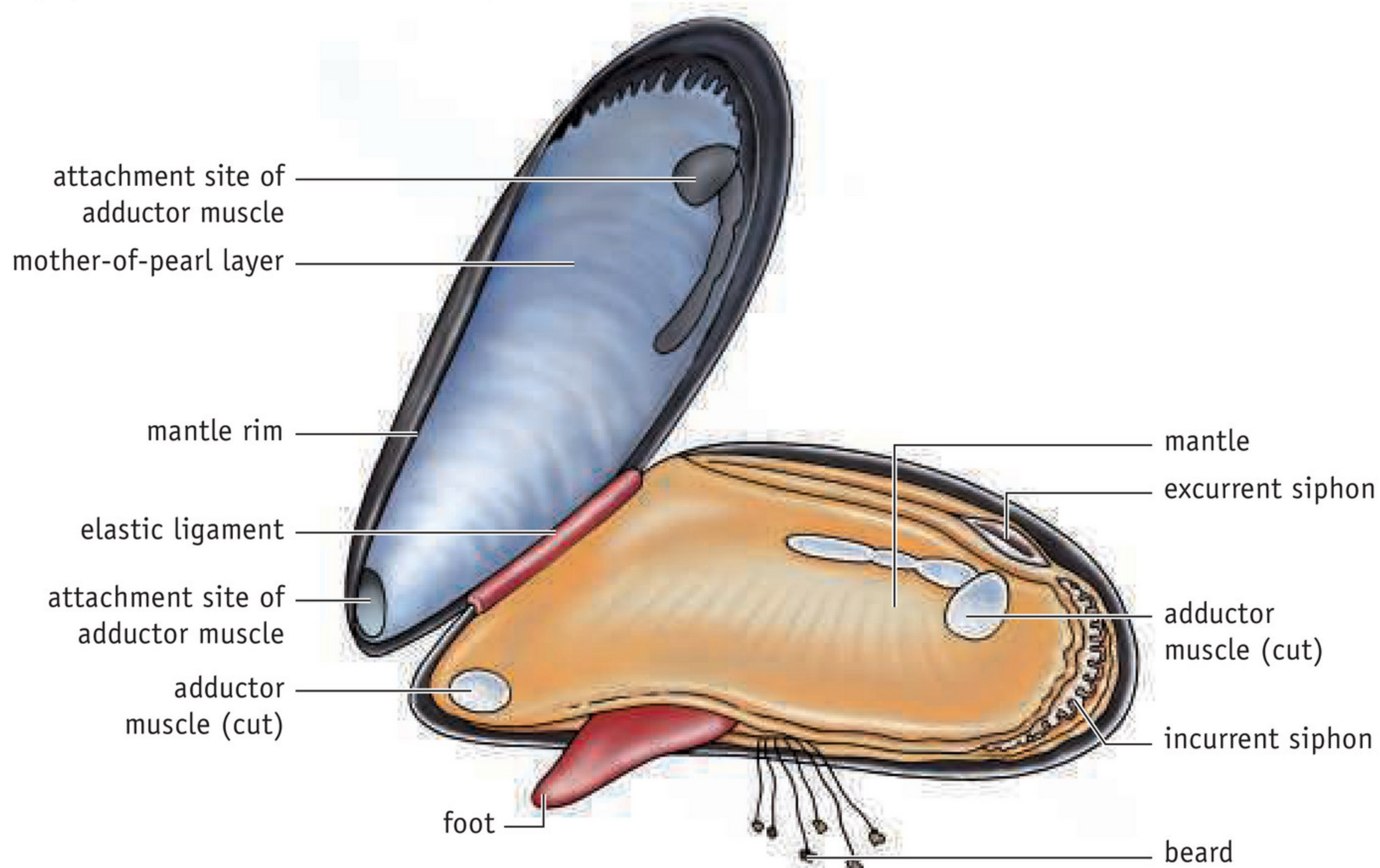


The body of the mussel has two adductor muscles (see figure 4). These are what pull the two halves of the shell tightly closed. When the adductor muscles relax, the springiness of the elastic ligament makes the two shells hinge open.

The mantle is up against both the shells (see figure 3). Cooking the mussel has probably already made it come away largely from one of the shells.

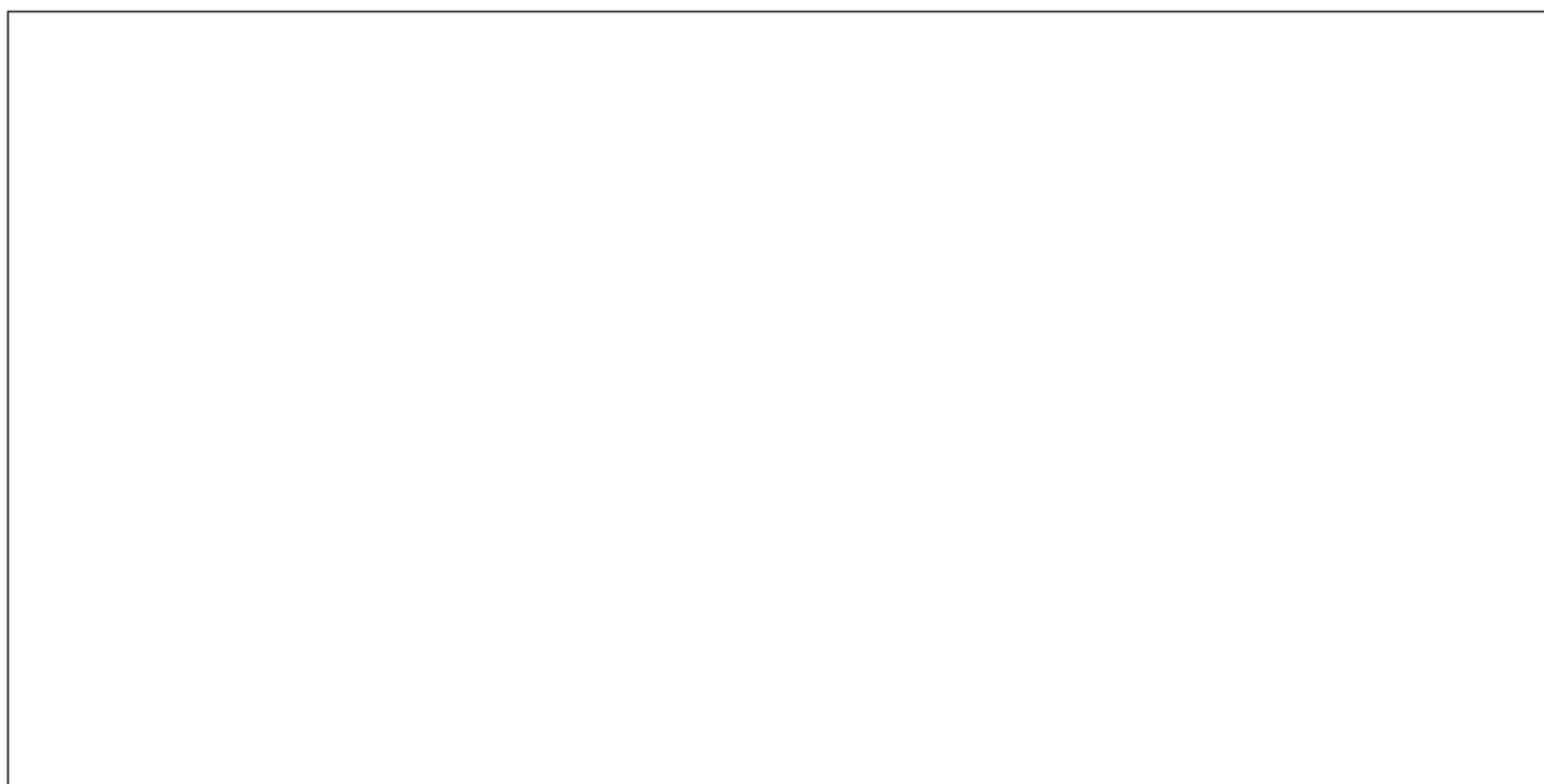
- Use the scalpel or blade to cut the mussel away entirely from the top shell. To do this, you have to cut through both adductor muscles. Then fold the shell open (see figure 4).

fig. 4 Mussel with the shell folded open.



In the opened shell, you can see the attachment site scars of the adductor muscles and the mother-of-pearl layer (see figure 4). You will also be able to see the mantle rim. That is the outer edge of the pearly layer. This is where the mantle had been attached.

- Make a drawing of the opened shell (the shell that the mussel is not in). Label the following parts: *attachment scar of the adductor muscle* (2×) – *mantle rim* – *pearly layer*.

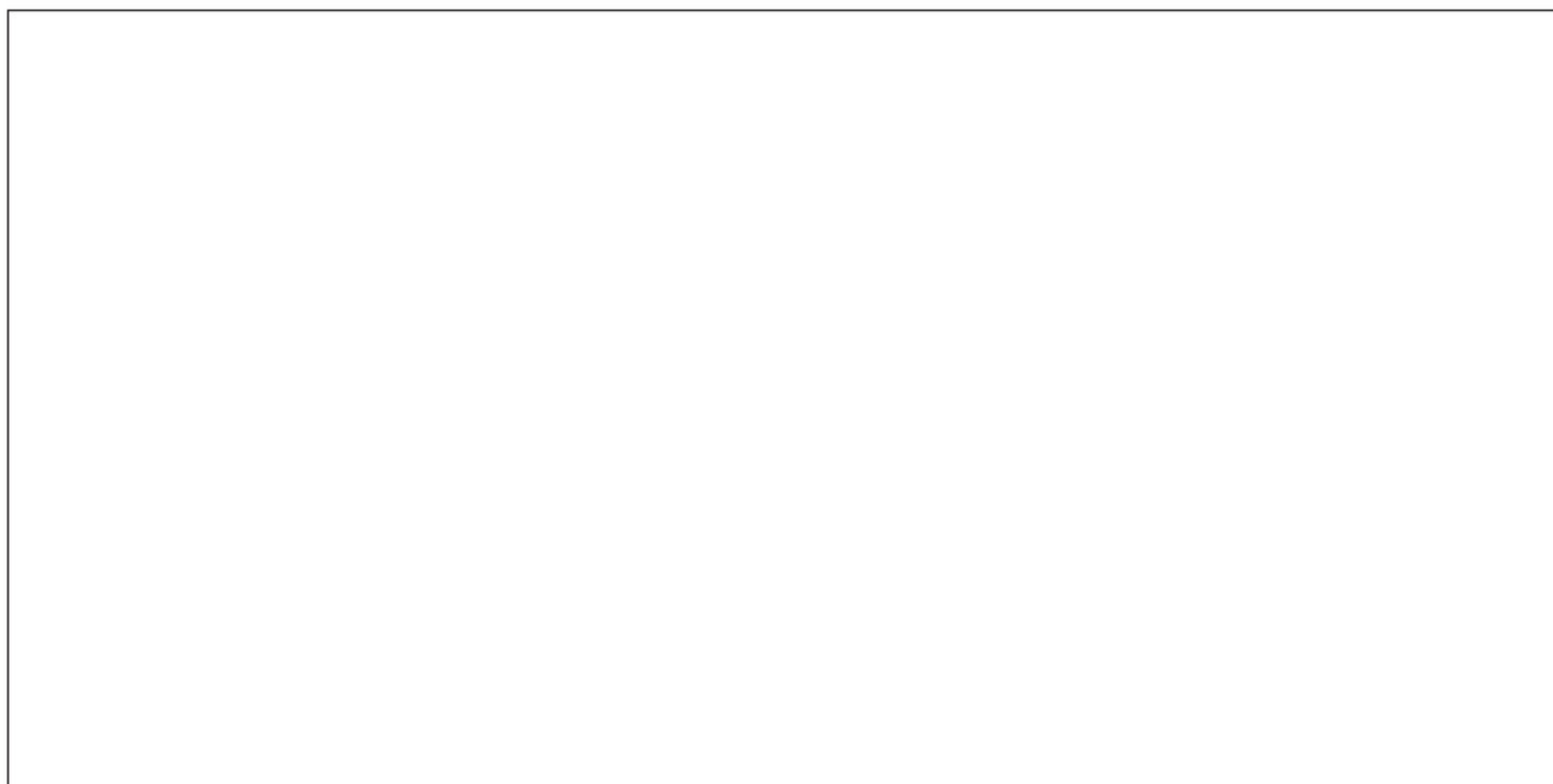


- Remove the opened shell. Examine the other shell (with the mussel). You can see the mantle and the cut adductor muscles (see figure 4). The foot may be sticking out from under the mantle. A mussel can use its foot to move slowly. In saltwater mussels, the foot is generally small.

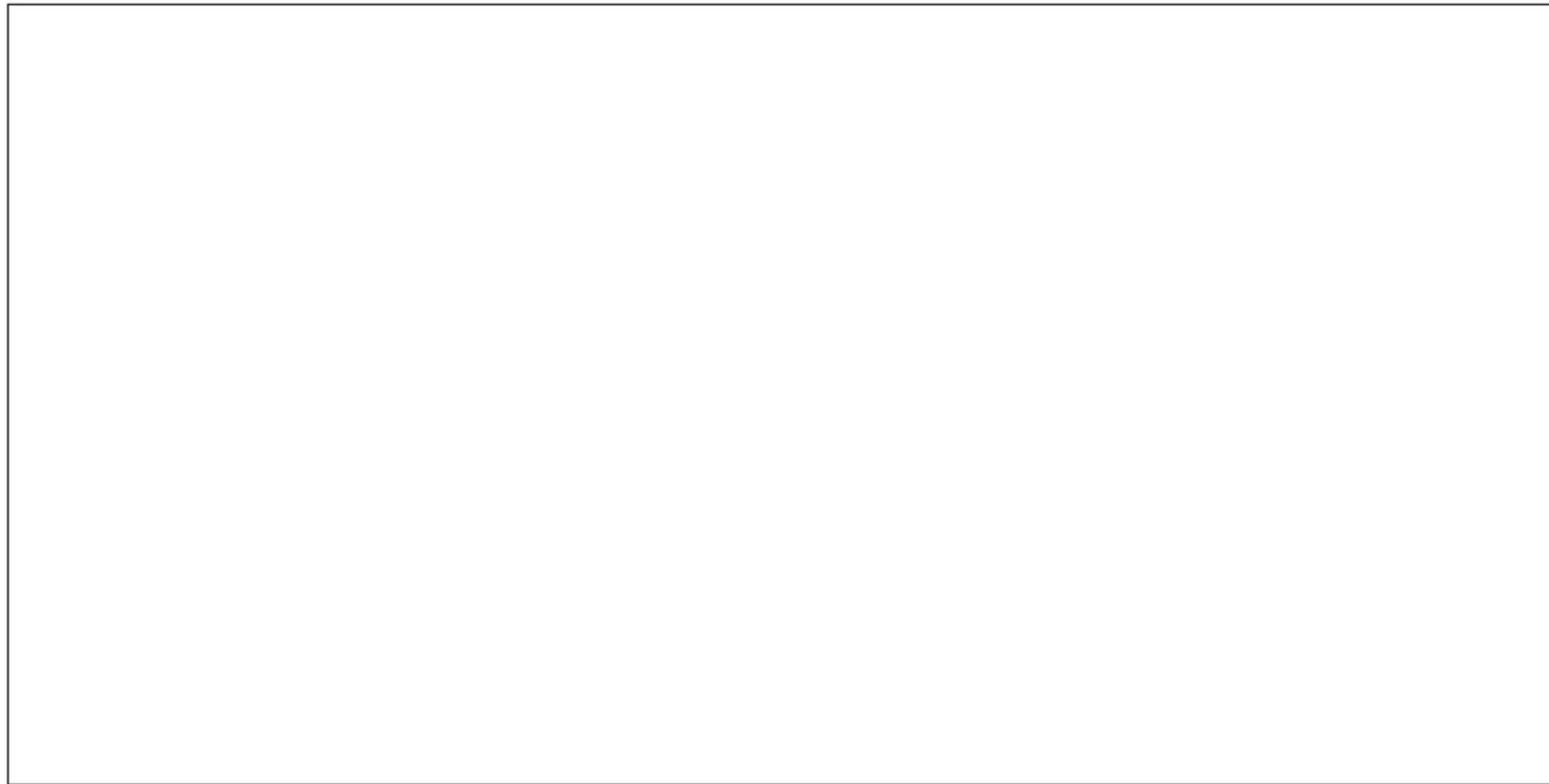
A saltwater mussel has a beard that holds it tightly in place. This beard is made of threads. Because these threads break off easily, you may not find any on the mussel you are examining.

On one side of the mussel, there are two openings between the left and right halves of the mantle: the incurrent siphon and the excurrent siphon (see figure 4). Figure 5 shows you a front view of a mussel with the incurrent and excurrent siphons marked.

- Make a drawing of the mussel in the shell. Label the following parts: *beard* (if you can see one) – *cut adductor muscles* (2×) – *incurrent siphon* – *mantle* – *foot* (if this is sticking out from under the mantle).



- Lay the mussel down so that you are looking at the incurrent siphon and excurrent siphon from the front. Make a drawing of this. Label the following parts:
incurrent siphon – excurrent siphon.

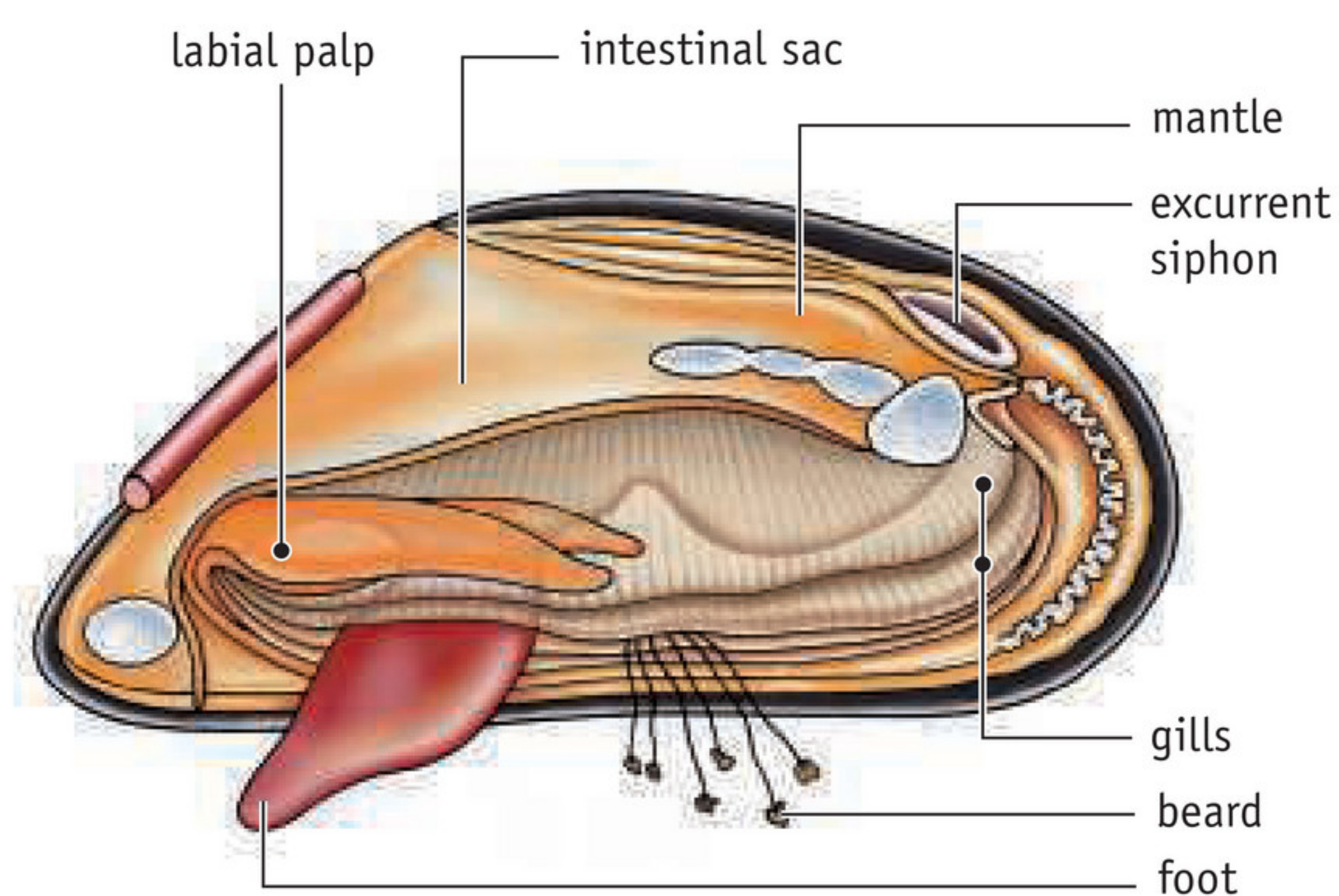


- Use the scissors to cut as much of the mantle away as possible, without damaging the underlying tissues (see figure 6). You will now definitely be able to see the foot and the (remains of) the beard. The gills can be seen as thin membranes in the mantle cavity (see figure 6). The cooking has probably made the gills shrink (a lot).

fig. 5 Mussel (front view)



fig. 6 Mussel with mantle cut away.



At the side by the foot, you can see the labial palps (see figure 6). The labial palps are located around the mouth. The mouth is difficult to see. The rest of the mussel is the intestinal sac.

- Draw the mussel with its mantle cut away. Label the following parts: *beard* – *intestinal sac* – *gill* – *labial palp* – *foot*.

2

MOSSES AND FERNS

► Basics 4 | ► Learning objective 3.4.10

 15-25 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be examining a spore capsule and a sporangium using a magnifying glass. You will make drawings.

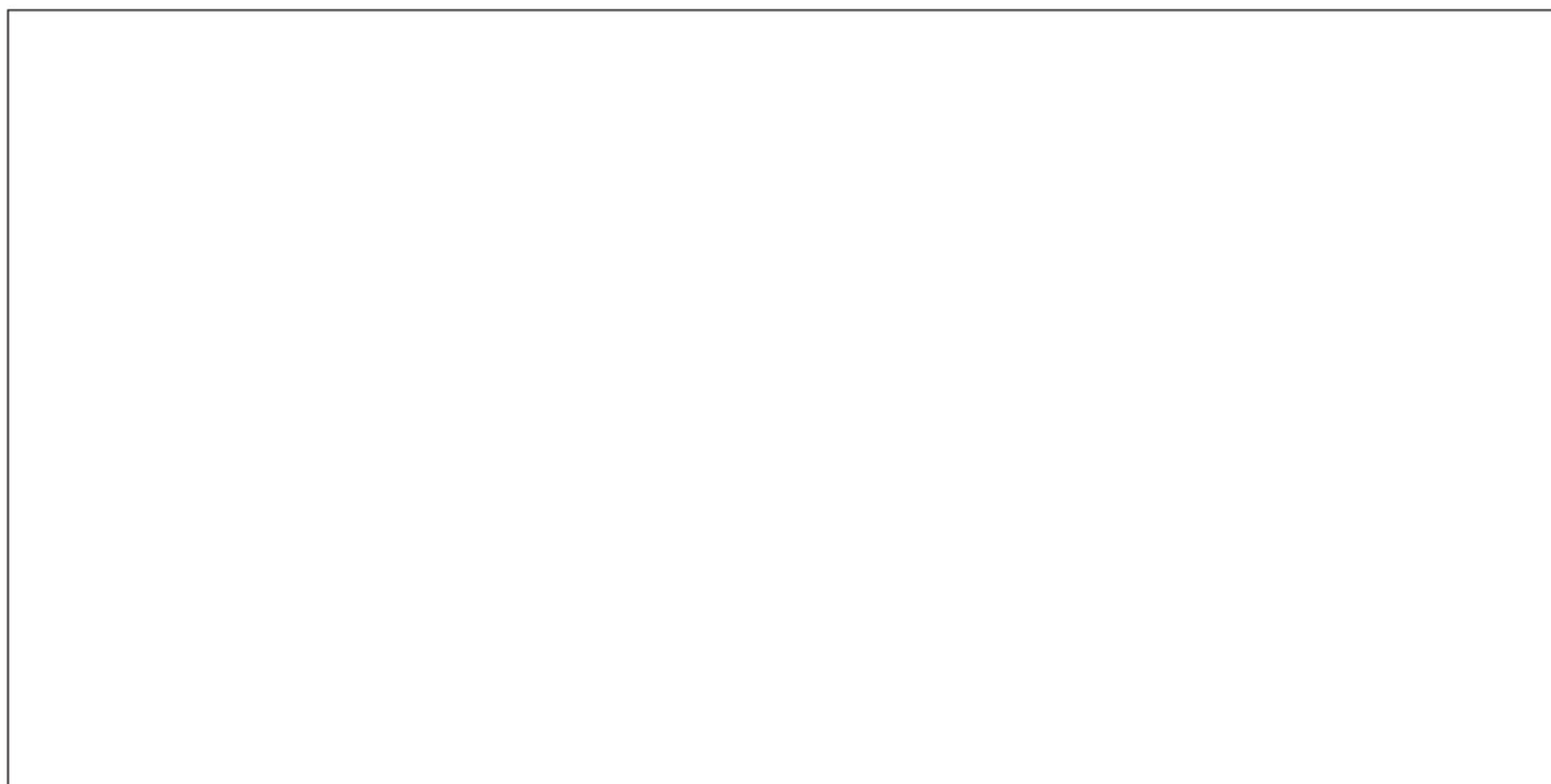
WHAT DO YOU NEED?

- ☐ a moss plant (such as common hair moss) with a spore capsule
- ☐ part of a fern frond (for examples from a male fern) with sporangia
- ☐ a magnifying glass
- ☐ drawing materials

WORKING METHOD

- Examine the moss plant under the magnifying glass.
- Make a drawing of the moss plant in the space provided. Label the *spore capsule*.

- Examine the underside of the fern frond under the magnifying glass.
- Make a drawing of a piece of a frond. Label a *sporangium*.



3

PLEUROCOCCLUS

► Basics 4 | ► Learning objective 3.4.9

 25-30 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be using a microscope to examine a green alga (Pleurococcus). You prepare the specimen yourself and draw what you see.

WHAT DO YOU NEED?

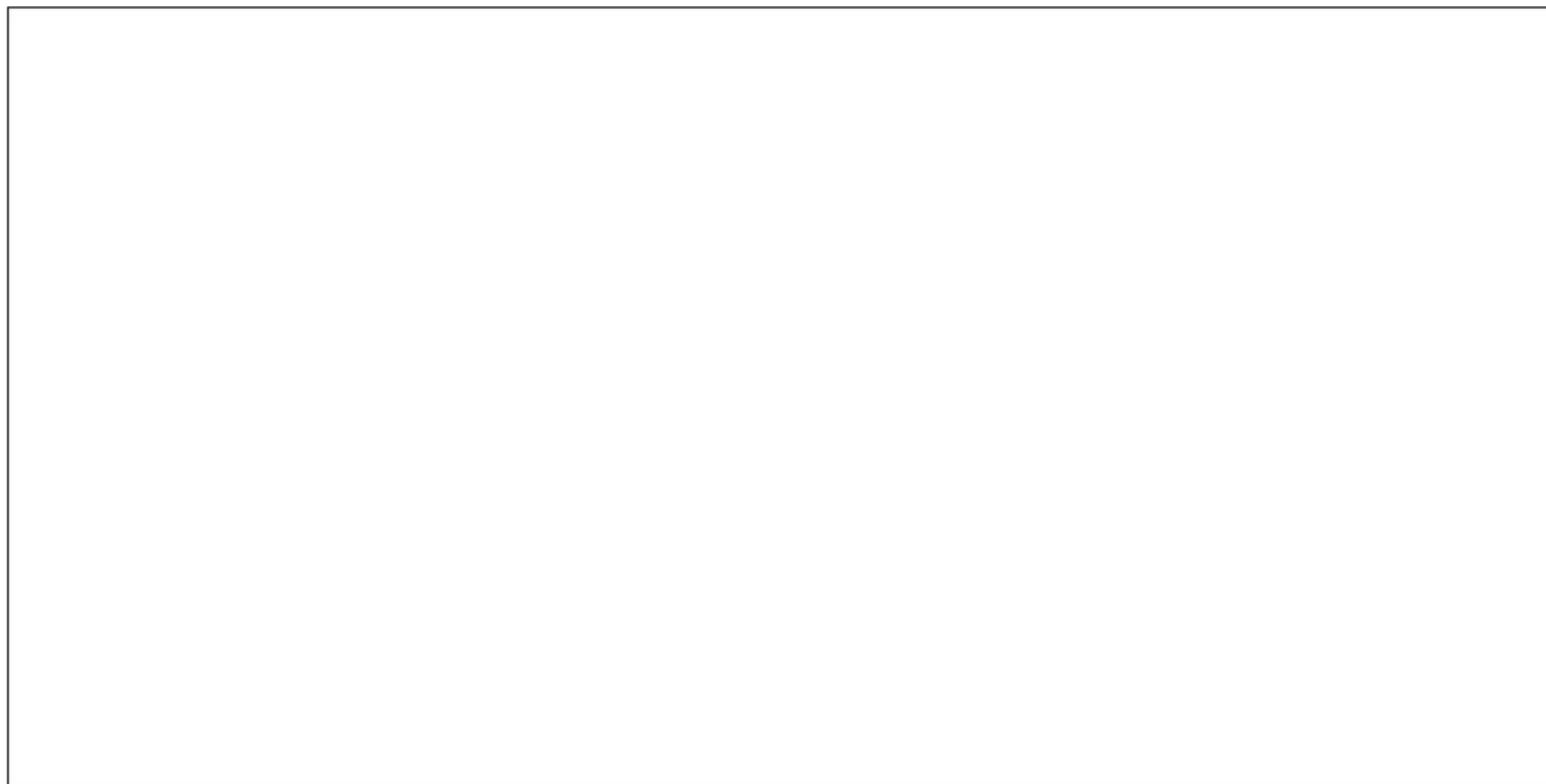
- ☐ a piece of tree bark with a green algal deposit on it (Pleurococcus)
- ☐ a microscope
- ☐ preparation materials
- ☐ drawing materials

WORKING METHOD

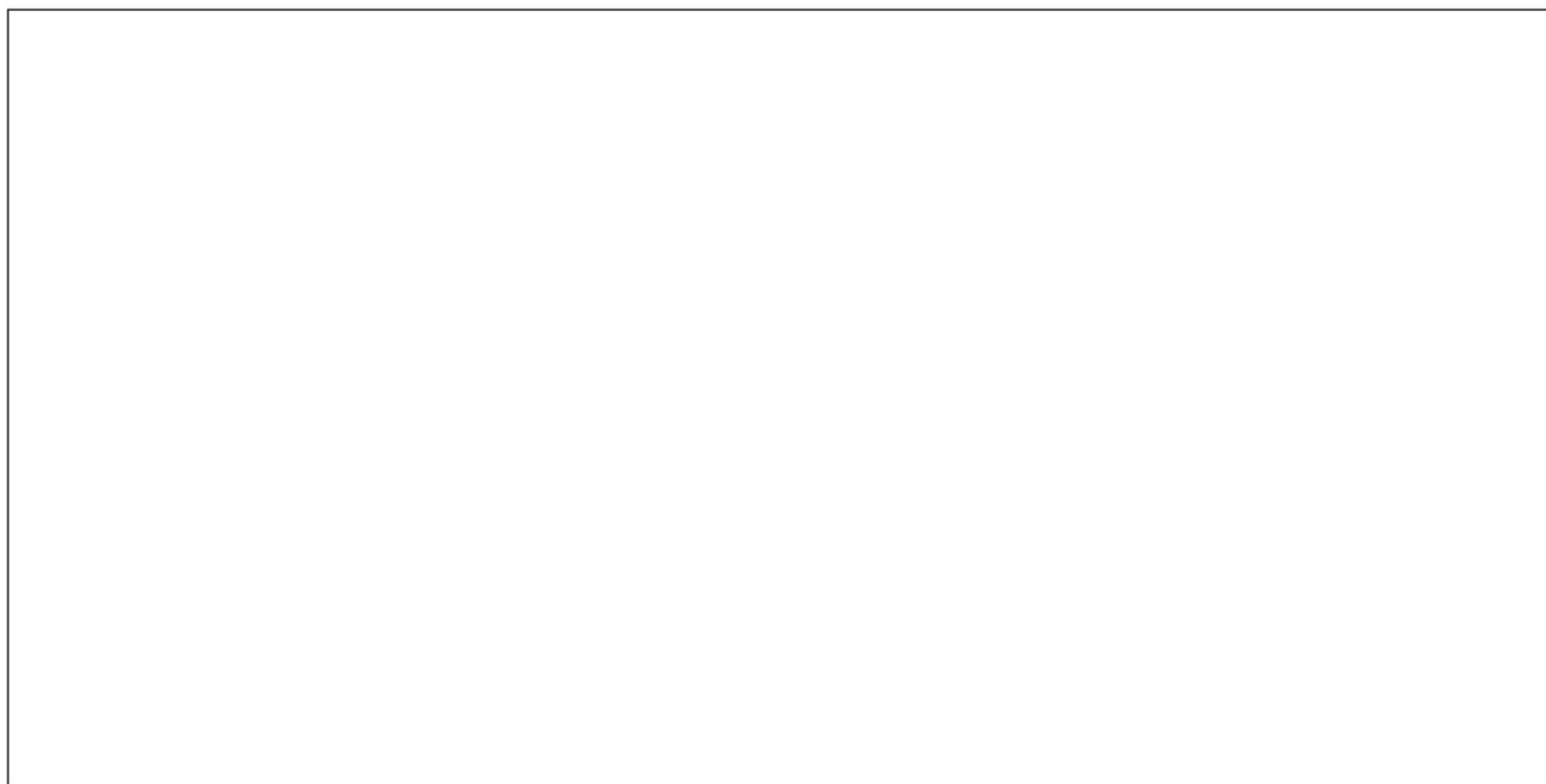
- Scrape off a little bit of the green deposit from the tree bark. You only need a very tiny bit. Make a specimen from this. Press down gently on the coverslip with your finger and move it in a circular motion (see figure 7).
- Examine the specimen using a magnification of 400×. You will see individual Pleurococcus cells with cell walls. You will also see groups of Pleurococcus cells that are still stuck together. This happens because the cells do not come away from each other straight away after dividing.
- Examine a single Pleurococcus cell at a magnification of 400×.
- Make a drawing of the green algal cell. Be careful to note the thickness of the cell wall.

fig. 7





- Examine a group of two to four *Pleurococcus* cells that are still stuck together at 400 $\times$ magnification.
- Make a drawing of these green algae cells.



4

YEAST CELLS

► Basics 5 | ► Learning objective 3.5.11

 30-35 minutes

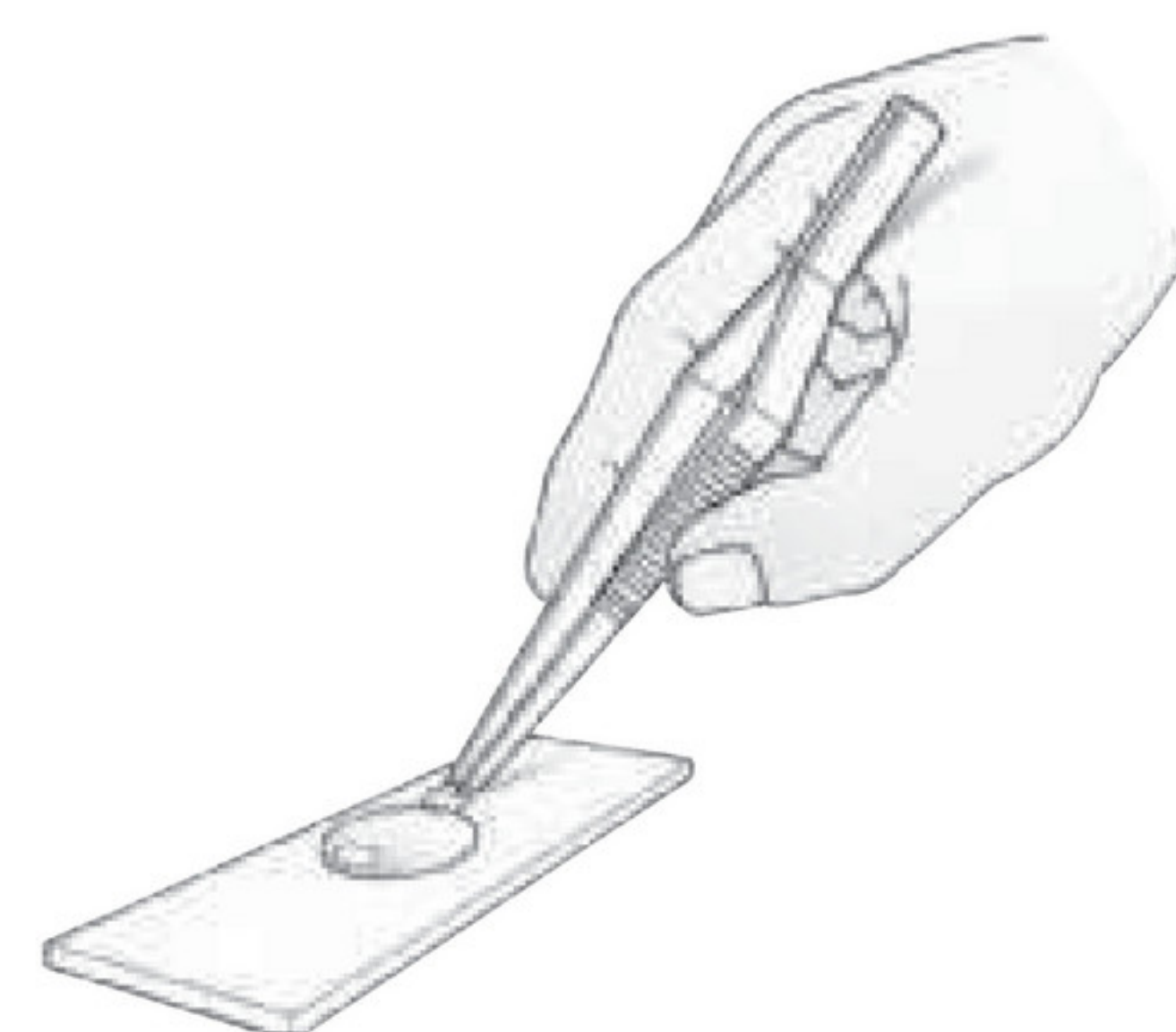
WHAT ARE YOU GOING TO DO?

In this practical activity, you will be using a microscope to examine yeast (a fungus). You prepare the specimen yourself and draw what you see.

WHAT DO YOU NEED?

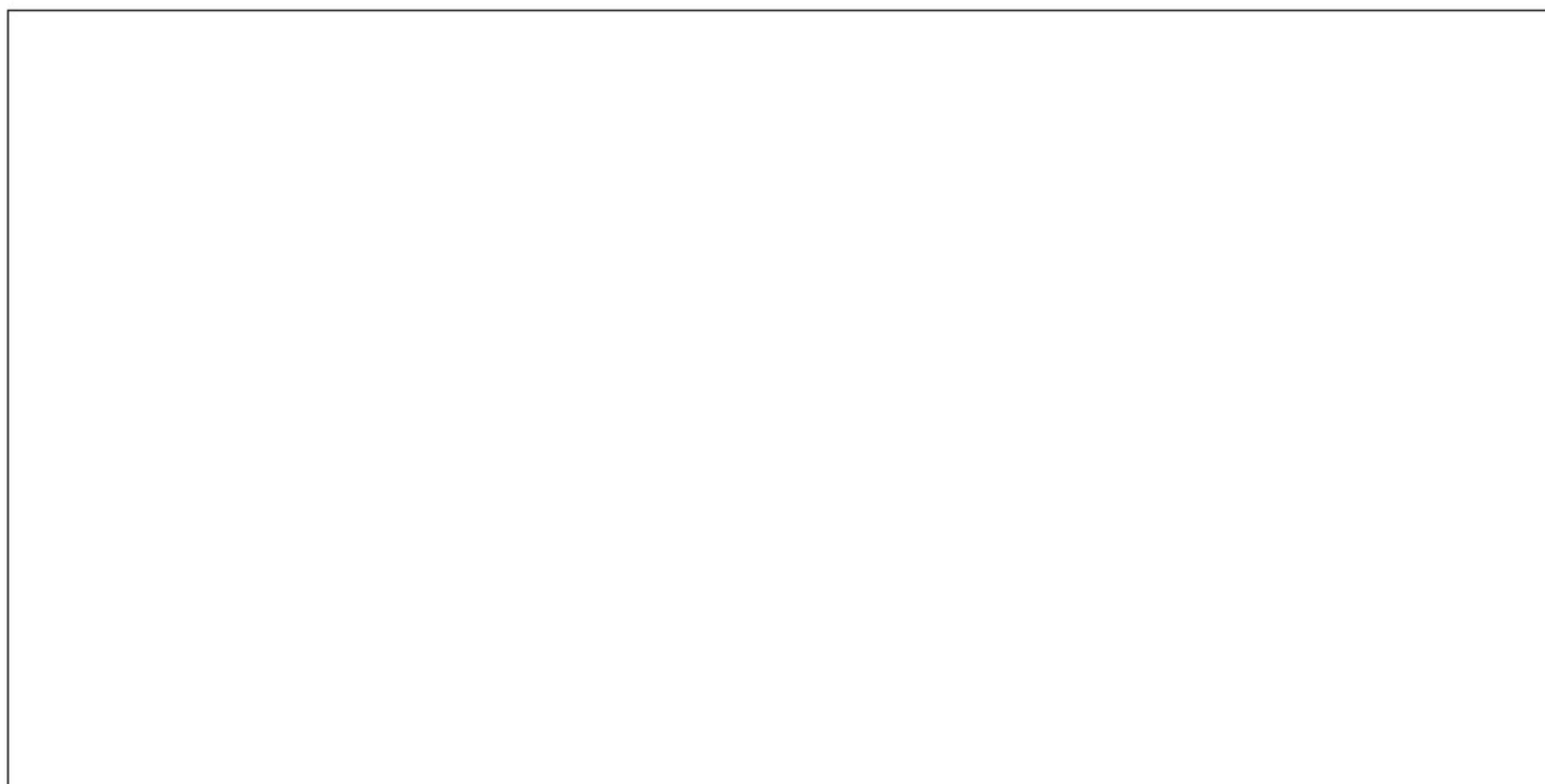
- ☐ a lump of baker's yeast
- ☐ a microscope
- ☐ preparation materials
- ☐ drawing materials

fig. 8

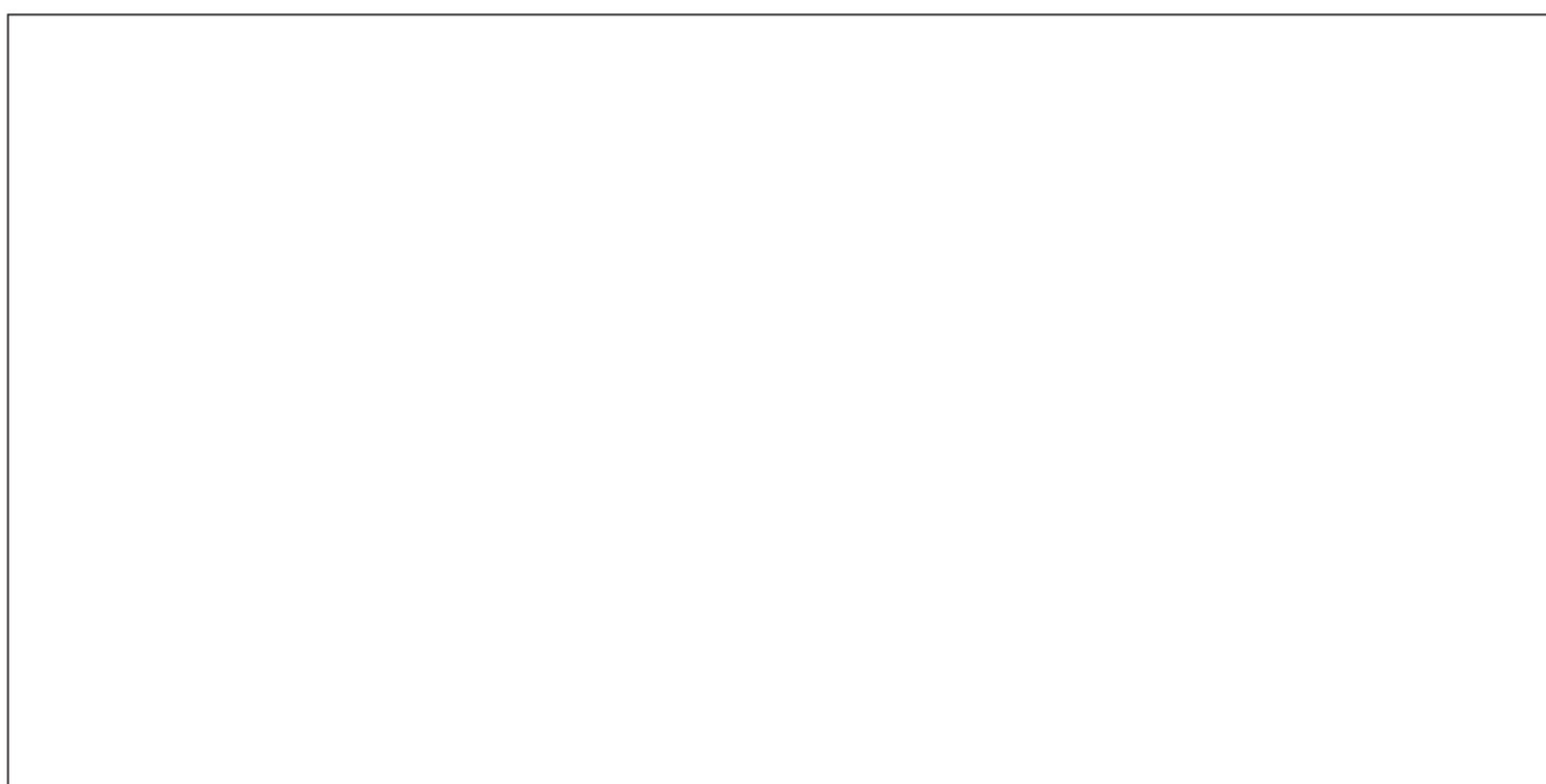


WORKING METHOD

- Make a preparation of yeast cells. Do this by taking a piece of yeast with the tweezers and holding it against the edge of a drop of water on the slide (see figure 8). Make sure that the yeast stays in contact with the water for a little while. Take the piece of yeast away when the drop of water has gone cloudy.
- Examine the slide at a magnification of 100 $\times$. You will see large, fully grown yeast cells and smaller ones that have not yet finished growing. On the large, fully grown yeast cells you will sometimes see small lumps growing (see figure 1 in Basics 5). This is where a new yeast cell is being produced by division.
- Examine a fully grown yeast cell at a magnification of 400 $\times$.
- Make a drawing of the grown yeast cell. Be careful to note the thickness of the cell wall.



- Examine a budding yeast cell at a magnification of 400 $\times$.
- Make a drawing of the yeast cell with its bud. Be careful to note the thickness of the cell wall.



5

MULTICELLULAR FUNGI

► Basics 5 | ► Learning objective 3.5.11

 30-35 minutes**WHAT ARE YOU GOING TO DO?**

In this practical activity, you will be using a microscope to examine mould on a piece of food. You prepare the specimen yourself and draw what you see.

WHAT DO YOU NEED?

- ☐ A mouldy slice of bread or a mouldy piece of fruit (see figure 9)
- ☐ a magnifying glass
- ☐ a microscope
- ☐ preparation materials
- ☐ drawing materials

WORKING METHOD

- Examine the fungi under the magnifying glass.
- Use the tweezers to pull off a small piece of mould (choose a 'furry' piece of the mould). Make a specimen from this.
- Examine the slide at a magnification of 100×. You will see the fungal filaments and perhaps also spores at the ends of the threads. You also often see loose spores.
- Examine a piece of mould from the specimen that is nice and clear at a magnification of 400×.
- Make a drawing of a few fungal filaments (hyphae), preferably ones with spores at the ends. Otherwise, draw the loose spores. Label the following parts: *hypha* – *spore*.

fig. 9 A mouldy piece of fruit.

6 FUNGAL GROWTH

► Basics 5 | ► Learning objectives 3.O.19 and 3.O.20 | ► Learning how to do research 3

 Lesson 1: 10-15 minutes, lesson 2: 10-20 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be investigating whether bread moulds grow more quickly in dry or damp places.

WHAT DO YOU NEED?

The things you need are given in the table.

fig. 10 A mouldy piece of bread.



WORKING METHOD

Do the practical activity and complete the rest of the table.

RESEARCH	MOULD GROWTH		
Research question	Does bread mould grow more quickly in dry or moist places?		
Hypothesis			
What do you need?	☐ A dried-out slice of bread ☐ An ordinary slice of bread ☐ A damp slice of bread ☐ 3 sandwich bags ☐ a permanent marker pen		
Working method	- I will label the three sandwich bags and write down what I have put in each. - I will put a piece of dry bread in bag number 1. - I will put an ordinary piece of bread in bag number 2. - I will put a piece of damp bread in bag number 3. - I will look at the results after a week.		
Results	the most mould	less mould	the least mould
Conclusion			

You can also investigate whether bread mould (see figure 10) grows more quickly in warm or cold places. Use the same table as for investigating bread mould growth in dry or damp places.

7

CULTURING BACTERIAL COLONIES

► Basics 6 | ► Learning objectives 3.O.19 and 3.O.20 | ► Learning how to do research 3

 Lesson 1: 15-20 minutes, lesson 2: 10-15 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you are going to culture bacterial colonies. Carry out the exercise in the table and then complete the rest of it.

WHAT DO YOU NEED?

The things you need are given in the table.

WORKING METHOD

Do the practical activity and complete the rest of the table.

RESEARCH	CULTURING BACTERIAL COLONIES					
Research question	Which object contains the most bacteria?					
Hypothesis						
What do you need?	☐ one Petri dish with culture medium; the Petri dish has been divided into four sections, numbered 1 to 4, using a marker pen (see figure 11). ☐ drawing materials fig. 11 Petri dish with culture medium. 					
Working method	• ouch (inoculate) each part of the culture medium with one object that you want to test to see if bacteria are present. This could be a coin, a page from your exercise book, a dirty finger, a finger that has just been washed, and so on. • The ‘Results’ section has four boxes. Make a note of the objects you have used for inoculating in each of the boxes. • Your teacher will collect the Petri dishes. • Examine the Petri dish after a few days. Examine the Petri dishes of some of your classmates too. • Make drawings of the bacterial colonies.					
Result	<table><tr><td>1 Inoculated with:</td><td>2 Inoculated with:</td></tr><tr><td>3 Inoculated with:</td><td>4 Inoculated with:</td></tr></table>		1 Inoculated with:	2 Inoculated with:	3 Inoculated with:	4 Inoculated with:
1 Inoculated with:	2 Inoculated with:					
3 Inoculated with:	4 Inoculated with:					
Conclusion						

Summary

BASICS 1

SMALLER AND SMALLER GROUPS

1 You can classify organisms into domains and kingdoms.

- A feature is a property you can use to distinguish one organism from other organisms.
- Life on Earth is classified into two domains:
 - prokaryotes (without a nucleus)
 - eukaryotes (with a nucleus)

	PROKARYOTES		EUKARYOTES				
KINGDOM	bacteria	archaea	chromista	protozoa	fungi	plants	animals

2 You can list the features of animal, plant, fungal and bacterial cells.

DOMAIN	KINGDOM	CELL FEATURES
PROKARYOTES	bacteria	• no nucleus • do have a cell wall • no chloroplasts
EUKARYOTES	fungi	• nucleus • cell wall • no chloroplasts
	plants	• nucleus • cell wall • chloroplasts
	animals	• nucleus • no cell wall • no chloroplasts

3 You can list the groups that are used for further classification within a kingdom.

- Further categorisation of a kingdom gives smaller groups (in sequence, largest first):
kingdom → phylum → class → order → family → genus → species
For example, the arthropod phylum is subdivided into the classes of arachnids, crustaceans, insects and so forth. The class of insects is divided into the orders of beetles, butterflies, fleas and so forth.

BASICS 2

SIMILARITY AND KINSHIP

4 You can distinguish between species and breeds.

- Organisms belong to the same species if they can reproduce together and the offspring are also fertile.
- A species can be made up of several breeds (or races).
 - The external appearance of the breeds can be very different.
 - Different breeds within the same species can reproduce together. Example: different breeds of dogs.

5 You can explain how the classification of organisms depends on similarity and kinship.

- The more similarities there are between two organisms, the more they will be classified into the same groups.
- Evolution: new species can arise through variation and selection.
 - These species arise from a common ancestor.

- Species with a common ancestor are related.
 - The longer ago that common ancestor lived, the smaller the degree of kinship between the species.
 - The more closely related two species are, the more similar their DNA will be.

BASICS 3

ANIMALS

6 You can classify animals based on the features 'skeleton' and 'symmetry'.

- Symmetrical means that you can divide it into two equal halves.
 - bilaterally symmetrical: there is only one way to cut the object into equal halves
 - radially symmetrical: there are several ways to cut the object into equal halves
 - asymmetrical: there is no way to cut the object into equal halves
- The sturdy parts in the body of an animal are called the skeleton.
 - The skeleton provides rigidity and protection.
 - internal skeleton: inside the body
 - external skeleton: on the outside of the body

7 You can list features and examples of six phyla of the animal kingdom.

	Features	Examples
Sponges	• asymmetrical • a skeleton of tough keratin fibres between the cells • mostly fixed in place on the seabed	• yellow tube sponge • purple tube sponge
Cnidarians	• radially symmetrical • do not generally have a skeleton • live in water • catch their prey with tentacles	• compass jellyfish • sea anemone
Molluscs	• bilaterally symmetrical • generally have a shell as a skeleton	• squid • mussel • snail
Arthropods	• bilaterally symmetrical • external skeleton (cuticle) • jointed legs • the body consists (at least partly) of segments	• centipede • crab • spider • fly
Echinoderms	• radially symmetrical • internal skeleton of calcium carbonate • the skin is covered with spines or nodules • live on the seabed	• sea urchin • sea cucumber • starfish
Vertebrates	• bilaterally symmetrical • an internal skeleton with a spinal column	• badger • frog • sand lizard

BASICS 4

PLANTS

8 You can classify plants into eight phyla.

KINGDOM	plants							
	non-green plants		green plants					
PHYLUM	blue-green algae	red algae	green algae	stoneworts	hornworts	mosses	liverworts	vascular plants

- 9 You can name the features of vascular plants and green algae and you can give examples of them.**
- Vascular plants have vessels for transporting substances.
 - examples: all seed plants, ferns, horsetails
 - Green algae.
 - single-celled or multicellular organisms with chloroplasts
 - no roots, stems or leaves
 - examples: Pleurococcus (single-celled), sea lettuce (multicellular)
- 10 You can list the features of spore-bearing plants and seed plants and you can give examples of them.**
- Two ways that plants reproduce are:
 - through spores: cells from which a new plant can grow
 - through seeds that are produced in flowers

	Features	Examples
Spore-bearing plants	• leaves, stems, roots • no flowers • reproduction through spores	• hair moss • field horsetail • male fern
Seed plants	• leaves, stems, roots • do have flowers • reproduction through seeds	• beech • grass • poppy

BASICS 5

FUNGI

- 11 You can list features of fungi.**
- Fungi can be single-celled or multicellular.
 - Multicellular fungi consist (mostly) of mycelium.
 - Fungi cannot photosynthesise (they do not have chloroplasts).
 - Unicellular fungi such as yeasts reproduce by division.
 - A new yeast cell is produced from a bud.
 - Multicellular fungi mostly reproduce by spores.
 - In some types of fungus, the spores are produced in toadstools.
- 12 You can explain that fungi can be both useful and harmful and you can give examples of both.**
- Most types of fungus feed on the dead residues of organisms.
 - In nature, they clear up the remains of organisms.
 - They can make food go bad.
 - Fungi can cause diseases (e.g. athlete’s foot).
 - Fungal infections can be tackled with medicines.
 - Fungi can be used by people:
 - in producing medicines (e.g. penicillin)
 - in preparing foodstuffs (e.g. bread, beer, wine, blue cheese)
 - as food: the toadstools of some species of fungi can be eaten (e.g. mushrooms).
 - Biotechnology is a collective term for techniques in which people use living organisms to produce goods.

BASICS 6

BACTERIA

13 You can list features of bacteria.

- Bacteria are prokaryotes: single-celled organism without a nucleus.
- Bacteria reproduce by division (fission).

14 You can explain that bacteria can be both useful and harmful and you can give examples of both.

- Most species of bacteria feed on the dead residues of organisms.
 - In the soil, they clear up the remains of dead organisms.
 - They can make food go bad.
- Many bacteria are useful for humans:
 - Bacteria in the gut help you digest your food.
 - A layer of bacteria on your skin protects against pathogens.
 - Bacteria are used in the preparation of some foods (e.g. yoghurt, sauerkraut);
- Bacteria can cause infectious diseases (e.g. cholera, pneumonia, ear infections and tuberculosis).
 - Infectious bacterial diseases can be tackled with antibiotics.

EXTRA 7

VERTEBRATES (IN DEPTH)

15 You can list the features of five groups of vertebrates and you can give examples of them.

- Vertebrates have an endoskeleton (internal skeleton).
- There are five features that can be used to distinguish between the vertebrate classes:
 - skin
 - body temperature
 - respiratory organs
 - method of reproduction
 - living environment

Group	Features	Examples
Fishes	• skin covered in scales and slime • cold-blooded • breathe using gills • reproduction: eggs with no shells • living environment: in the water	• trout • herring • cod • plaice • pike
Amphibians	• skin covered with mucus (slime) • cold-blooded • breathe using gills and skin at first, later with lungs and through the skin • reproduction: eggs with no shells • living environment: in water and on land	• frog • toad • newt
Reptiles	• skin covered with dry scales • cold-blooded • breathe using lungs • reproduction: eggs with leathery shells • living environment: on the land	• lizard • crocodile • grass snake • tortoise
Birds	• skin covered with feathers • warm-blooded • breathe using lungs • reproduction: eggs with calcium carbonate shells • living environment: in the air	• buzzard • grebe • blackbird • owl • swallow
Mammals	• skin covered with hair/fur • warm-blooded • breathe using lungs • reproduction: viviparous, young drink milk (suckle) from the mother • living environment: on the land	• dog • elephant • human • wolf • tiger

EXTRA 8

ARTHROPODS (EXTENSION)

16 You can list the features of five groups of arthropods and you can give examples of them.

- Arthropods have an external skeleton (cuticle).
- The legs of arthropods have jointed segments (smaller sections).
- The bodies of arthropods are segmented (made up of smaller sections).

Group	Class	Features	Examples
Hexapods	e.g. insects	• six legs • head, thorax and abdomen • legs and (often) wings are on the thorax	• beetle • ant • butterfly
Chelicerates	e.g. arachnids	• eight legs	• harvestman • house spider
Crustaceans	e.g. higher crustaceans	• ten or more legs	• shrimp • lobster
Myriapods	e.g. centipedes	• the entire body is made up of segments • there are legs on each segment	• brown centipede • giant centipede

RESEARCH

LEARNING HOW TO DO RESEARCH & PRACTICAL ACTIVITIES

- 17 You can describe the steps in scientific research.**
- 18 You know the various types of scientific research.**
- 19 You can carry out research according to a work plan.**
- 20 You can draw one or more conclusions that answer the research question.**
- 21 You can use an identification table.**

 Go to the *Flash cards* and the *Diagnostic test*.



Worksheet 1

for unit 3, extras 8, exercise 4

- is very small
- lives in the water
- is used as fish food

- lives in the sea
- uses pincers to grab its food
- the body is short and broad

- is grey or brown
- can often be found under stones, in dead wood or in cellars

- lives in large groups; the nests are below ground
- can sometimes give a nasty bite
- can often be seen carrying all sorts of things

- occur a lot in the home
- has a pointed nose that it can use to “bite”
- then sucks blood, after which it makes you itchy

- is an insect: eats insects, spiders and worms
- has a lot of legs (between 30 and 354)

- is a predatory insect: eats aphids
- is usually red with black spots

- is a predatory insect: eats aphids
- is usually red with black spots

- is very small
- lives in the fur of animals (e.g. cats)
- can bite and then sucks the blood

- weaves a web in which insects are caught
- you see them above all during the autumn

- is small and green
- lives on the stems of plants and on the undersides of leaves
- sucks the plant's sap

- is yellow and black
- has a sting

- is mostly green
- can jump very well and can fly
- can be found in huge numbers in the tropics and cause plagues

- can look very different (it is actually a collective name for a large family of insects)



- can come in lots of different colours
- was a caterpillar as a young animal

- gets nectar out of flowers and turns it into honey
- is kept in hives by humans
- has a sting

- is generally black
- occur a lot in the home
- makes a quiet buzzing sound as it flies

Glossary

A

abdomen achterlijf

Achterste deel van een insect.

adult volwassene

Persoon van 21 tot 65 jaar; tijdens deze periode is een persoon geheel zelfstandig.

altricial nestblijver

Dier dat na de geboorte hulpeloos is.

amoeba amoebe

Eencellig organisme dat zich voortbeweegt door het vormen van schijnvoetjes en voedsel verteert in voedingsvacuolen.

amyloplasts zetmeelkorrels

Plastiden waarin zetmeel is opgeslagen.

anal pore celanus

Deel van een cel waar onverteerde resten worden verwijderd.

annual ring jaarring

Al het hout in een boomstam dat in één jaar is gevormd.

antibiotic antibioticum

Geneesmiddel dat bacteriën doodt.

arm statief

Deel van de microscoop waaraan je hem vastpakt.

asymmetric niet-symmetrisch

Op geen enkele manier in twee gelijke helften te verdelen.

B

baby baby

Kind van 0 tot 1,5 jaar; tijdens deze periode groeit een kind snel.

bands bandjes

Streepjes die het aantal herhalingen van dezelfde basenvolgorde in het DNA weergeven.

base pair basenpaar

Twee basen die precies in elkaar passen, dit zijn: A-T en C-G.

bases basen

Vier onderdelen van DNA die worden aangegeven met de letters: A, T, C en G.

bilateral symmetry tweezijdig symmetrisch

Op één manier in twee gelijke helften te verdelen.

biotechnology biotechnologie

Een verzamelnaam voor technieken waarbij mensen organismen gebruiken om producten te maken.

blade bladschijf

Het platte gedeelte van een blad.

body cells lichaamscellen

De cellen waaruit je lichaam is opgebouwd.

body segments segmenten

Stukjes waaruit een deel van het lichaam van geleedpotigen is opgebouwd.

branching tree vertakkingsschema

Schema waarin je de indeling van organismen in steeds kleinere groepen kunt weergeven.

breed ras

Groep waarin je de organismen van één soort kunt indelen.

bud knop

Hieruit ontstaat een nieuwe gistcel.

C

cambium cambium

Laag cellen dicht onder de schors die nieuw hout vormt richting het midden van de boomstam.

camouflage schutkleur

Een kleur waarmee organismen zich bijna onzichtbaar maken voor vijanden.

cell cycle celcyclus

Het terugkerende proces van celdeling, groei, en weer een nieuwe celdeling.

cell division celdeling

Ontstaan van nieuwe cellen.

cell membrane celmembraan

Een dun vliesje om het cytoplasma.

cell organelles celorganellen

Delen van een cel met een eigen functie.

cell wall celwand

Een stevig laagje om een plantaardige cel.

cells cellen

Bouwstenen van organismen.

chloroplasts bladgroenkorrels

Plastiden waarin fotosynthese plaatsvindt.

chromoplasts kleurstofkorrels

Plastiden die bloemen en vruchten hun kleur geven.

chromosomes chromosomen

Dunne 'draden' bestaande uit DNA die alles regelen wat er in de cel gebeurt.

cilia trilhaartjes

Dunne uitsteeksels op het celmembraan van een pantoffeldiertje waardoor het kan bewegen en eten.

cocoon cocon

Omhuysel dat een rups heeft tijdens de metamorfose.

cold-blooded koudbloedig

De lichaamstemperatuur is gelijk aan de temperatuur van de omgeving.

conclusion conclusie

Deel van een onderzoek dat antwoord geeft op de onderzoeksvraag en laat zien of de hypothese juist was.

conical beak kegelsnavel

Korte snavel waarmee een vogel veel kracht kan zetten en daardoor geschikt is om zaden mee te eten.

coverslip dekglas

Dun glaasje dat je op een voorwerp legt dat je onder de microscoop wilt bekijken.

cytoplasm cytoplasma

Dikke vloeistof die bestaat uit water met opgeloste stoffen.

D**daughter cells** dochtercellen

Cellen die ontstaan bij celdeling.

dead dood

Iets wat vroeger heeft geleefd.

dehydration uitdroging

Te veel water verliezen.

descriptive research beschrijvend onderzoek

Onderzoek waarbij de onderzoeker beschrijft wat hij waarneemt.

development ontwikkeling

Proces waarbij de bouw van een organisme verandert.

diaphragm diafragma

Deel van een microscoop waarmee je de hoeveelheid licht regelt.

digitigrade teenganger

Een dier dat op zijn tenen loopt.

DNA kinship analysis DNA-verwantschapsonderzoek

Onderzoek waarbij het DNA van mensen wordt vergeleken om te bepalen of zij familie van elkaar zijn.

DNA profile DNA-profiel

Een tekening of tabel van het DNA van een persoon.

DNA DNA

Twee strengen opgebouwd uit vier basen die informatie voor je erfelijke eigenschappen bevatten.

E**elderly** oudere

Persoon van 65 jaar en ouder; tijdens deze periode kan een persoon last krijgen van lichamelijke problemen.

electron microscope elektronenmicroscop

Microscop waarmee je een voorwerp tot bijna 1 000 000× kunt vergroten.

embryonic stem cells embryonale stamcellen

Cellen waaruit alle verschillende typen cellen kunnen ontstaan.

endoskeleton inwendig skelet

Een skelet dat aan de binnenkant van een lichaam zit.

epidermis opperhuid

Een laag cellen aan de buitenkant van een blad die beschermt tegen invloeden van buitenaf.

eukaryotes eukaryoten

Organismen bestaande uit één of meerdere cellen met een celkern.

evolution evolutie

Ontwikkeling van het leven op aarde waarbij soorten ontstaan, veranderen en verdwijnen.

exoskeleton uitwendig skelet

Een skelet dat aan de buitenkant van een lichaam zit.

experimental research experimenteel onderzoek

Onderzoek waarbij experimenten worden gedaan om te kijken of de hypothese klopt.

external skeleton uitwendig skelet

Een skelet dat aan de buitenkant van het lichaam zit.

external view buitenaanzicht

De buitenkant van een organisme of voorwerp.

extracellular material tussencelstof

Vloeibare of harde stof die tussen de cellen ligt.

eyepiece lens oculair

Bovenste lens van een microscoop waar je doorheen kijkt.

F**feature** kenmerk

Eigenschap waarmee je een organisme kunt onderscheiden van andere organismen.

flattened beak zeefsnavel

Platte snavel waarmee een vogel water kan zeven en daardoor geschikt is om plankton te eten.

food reserves reservestoffen

Stoffen die een organisme niet meteen nodig heeft en opslaat voor later gebruik.

food vacuole voedingsvacuole

Blaasje in de cel waar voedsel wordt verteerd en vervolgens wordt opgenomen in het cytoplasma.

fossil fuels fossiele brandstoffen

Brandstoffen die zijn gevormd uit resten van dode organismen die miljoenen jaren geleden in de zeebodem terecht zijn gekomen.

G**gene** gen

Basenparen die samen nodig zijn voor één of meer eigenschappen.

germination kieming

Proces waarbij een zaad water opneemt.

glucose glucose

Energierijke stof die een plant aanmaakt door fotosynthese.

graph grafiek

Tekening met een horizontale en een verticale as waarin resultaten worden weergegeven.

green algae groenwieren

Eencellige of meercellige organismen met bladgroenkorrels.

growth spurt groeispurt

Periode van snelle groei.

growth groei

Groter en zwaarder worden.

H**head** kop

Voorste deel van een insect, hieraan zitten de ogen en voelsprieten vast.

herbaceous plants kruidachtige planten

Planten waarbij de stengels alleen stevig zijn als ze genoeg water kunnen opnemen.

hereditary characteristics erfelijke eigenschappen

Eigenschappen waarvoor je de informatie van je ouders erft.

hilum navel

Plaats waar het zaad vastzat aan de vrucht.

hooked beak haaksnavel

Scherpe snavel waarmee een vogel prooidieren in stukken kan scheuren.

hyphae schimmeldraden

Lange dunne draden van meercellige schimmels.

hypothesis hypothese

Mogelijk antwoord op een onderzoeksvraag.

I**identification** determineren

Organismen in een rijk, een stam of een klasse plaatsen door op de kenmerken te letten.

imago imago

Volwassen vlinder.

infection infectie

Besmetting met bacteriën of schimmels die ziekten veroorzaken.

internal skeleton inwendig skelet

Een skelet dat aan de binnenkant van een lichaam zit.

K**kingdom** rijk

Organismen binnen een hoofdgroep die zijn ingedeeld in kleinere groepen.

L**lamina** bladmoes

Materiaal in een blad dat tussen de nerven ligt.

large knob grote schroef

Deel van een microscoop waarmee je de tafel of de tubus van een microscoop beweegt.

larva larve

Een jong dier dat nog geen metamorfose is ondergaan.

lateral roots zijwortels

Vertakkingen van een hoofdwortel.

leaf stalk bladsteel

Deel van een blad waarmee het aan de stengel vastzit.

leg segments leden

Stukjes waaruit de poten van geleedpotigen zijn opgebouwd.

life processes levenskenmerken

Kenmerken die alleen levende organismen hebben.

lifecycle levenscyclus

Ontwikkeling van jong tot volwassen organisme.

light microscope lichtmicroscoop

Microscoop waarmee je een voorwerp tot bijna 1000× kunt vergroten.

literature study literatuuronderzoek

Onderzoek waarbij overeenkomsten en verschillen worden gezocht uit de informatie in artikelen.

living levend

Iets wat levenskenmerken heeft.

longitudinal section lengtedoorsnede

In de lengte doorsnijden.

M**mean** gemiddelde

Meerdere metingen bij elkaar opgeteld gedeeld door het aantal metingen.

mental development geestelijke ontwikkeling

Veranderingen van verstand, gevoelsleven en persoonlijkheid.

metamorphosis metamorfose

Veranderingen van lichaamsbouw en levenswijze van een dier.

micropyle poortje

Plaats waar het zaad water opneemt.

minerals mineralen

Opgeloste zouten in het water in de bodem die nodig zijn om planten in leven te houden.

motor development motorische ontwikkeling

Het leren van bewegingen.

mouth pore celmond

Instulping in de cel waar voedsel terechtkomt in een voedingsvacuole.

multicellular meercellig

Uit meerdere cellen bestaand.

N**non-living** levenloos

Iets wat nooit heeft geleefd.

nuclear membrane kernmembraan

Membraan om het kernplasma.

nuclear plasma kernplasma

Stof in de celkern.

nucleus celkern

Deel van een cel dat bestaat uit kernplasma en dat is omgeven door het kernmembraan, het regelt alles wat er in de cel gebeurt.

nutrients voedingsstoffen

Stoffen die nodig zijn voor de groei en ontwikkeling van een organisme.

O**objective lenses** objectieven

Onderste lenzen van een microscoop.

organ system orgaanstelsel

Groep van samenwerkende organen die gezamenlijk een bepaalde functie hebben.

organ orgaan

Deel van een organisme dat een bepaalde taak uitvoert.

organism organisme

Levend wezen.

P**paramecium** pantoffeldiertje

Eencellig organisme dat zich voortbeweegt door middel van trilhaartjes en voedsel verteert in voedingsvacuolen.

parent cell moedercel

Cel waaruit twee nieuwe cellen ontstaan door celdeling.

photosynthesis fotosynthese

Proces waarbij een plant glucose maakt met behulp van energie uit zonlicht.

physical development lichamelijke ontwikkeling

Veranderingen in het lichaam.

plant embryo kiem

Het beginsel van een nieuwe plant.

plantigrade zoolganger

Een dier dat op zijn hele voetzool loopt.

plasma growth plasmagroei

Groei van een cel door de toename van de hoeveelheid cytoplasma.

plastids plastiden

Korrels in een plantaardige cel met een speciale functie, bijvoorbeeld: bladgroenkorrels, kleurstofkorrels en zetmeelkorrels.

pointed beak priemsnavel

Lange snavel waarmee een vogel diep in een natte bodem kan prikken en daardoor geschikt is om bodemdierjes te eten.

precocial nestvlieder

Een dier dat snel na de geboorte het nest verlaat.

pre-school kleuter

Kind van 4 tot 6 jaar; tijdens deze periode leert een kind onder andere fietsen, tekenen en samen spelen.

prokaryotes prokaryoten

Organismen bestaande uit één cel zonder een celkern.

pseudopods schijnvoetjes

Uitsteeksels van een amoebe die gevormd worden doordat het cytoplasma in één richting stroomt.

puberty puberteit

Periode in het leven van een mens van 12 tot 16 jaar; tijdens deze periode begint de tweede groeispurt en vindt een sterke lichamelijke en geestelijke ontwikkeling plaats.

pupa pop

Omhulsel met een rups erin.

R

rack stop preparaatbeveiliging

Deel van een microscoop dat voorkomt dat het objectief tegen het preparaat komt.

radial symmetry veelzijdig symmetrisch

Op meerdere manieren in gelijke helften te verdelen.

raw materials grondstoffen

Stoffen waarvan producten worden gemaakt.

related verwant

Overeenkomsten in het DNA van verschillende organismen.

research question onderzoeksvraag

Vraag waar je antwoord op wilt vinden.

results resultaten

Waarnemingen en gegevens die je vastlegt.

revolving nosepiece revolver

Deel van een microscoop waarmee je een ander objectief kunt kiezen.

root hairs wortelharen

Dunne uitstulpingen aan de uiteinden van wortels.

root system wortelstelsel

Alle wortels van een plant.

S

schematic drawing schematische tekening

Tekening zonder details met alleen de belangrijkste kenmerken.

schoolchild schoolkind

Kind van 6 tot 12 jaar; tijdens deze periode leert een kind onder andere lezen, schrijven en rekenen.

scientific research natuurwetenschappelijk onderzoek

Onderzoek dat begint met een onderzoeksvraag en waarbij vaak experimenten gedaan worden.

seed coat zaadhuid

Beschermend vliesje om een zaad.

seed leaves zaadlobben

Onderdeel van een zaad waarin voedingsstoffen opgeslagen zijn die verbruikt worden tijdens de kieming.

seed plants zaadplanten

Planten met wortels, stengels, bladeren en bloemen.

selection selectie

Proces waarbij meer nakomelingen overleven van één variant dan van andere varianten.

senior citizen bejaarde

Persoon van 65 jaar en ouder; tijdens deze periode heeft een persoon vaak hulp nodig.

single-celled organisms eencellige organismen

Organismen die bestaan uit één cel.

skeleton skelet

Stevige delen van een dier.

slide voorwerpglas

Dik glaasje waar het voorwerp op ligt dat je door een microscoop wilt bekijken.

small knob kleine schroef

Deel van een microscoop waarmee je nauwkeurig kunt scherpstellen.

specialised cell gespecialiseerde cel

Cel met een bepaalde functie.

specimen preparaat

Voorwerp dat je onder een microscoop wilt bekijken.

spore spore

Cel waaruit een nieuwe plant kan ontstaan.

spore-bearing plants sporenplanten

Planten met wortels, stengels en bladeren, maar geen bloemen.

stage clips preparaatklemmen

Deel van een microscoop waarmee je een preparaat vastklemt aan de tafel.

stage tafel

Deel van een microscoop waar je een preparaat oplegt.

stages of life levensfasen

Fasen waarin lichamelijke, geestelijke of motorische ontwikkelingen plaatsvinden.

stages stadia

Fasen in het leven van een dier bij metamorfose.

stem cells stamcellen

Cellen die zich oneindig vaak kunnen delen.

stomata huidmondjes

Kleine openingen in een blad van een plant, die koolstofdioxide opnemen uit de lucht en zuurstof afgeven.

streamlined gestroomlijnd

Geleidelijk in elkaar overgaan.

suckle zogen

Melk geven van een moeder aan haar jongen.

symmetrical symmetrisch

In twee gelijke helften te verdelen.

T

table tabel

Schema met rijen en kolommen.

tap root hoofdwortel

De wortel van een plant die naar beneden groeit.

teenager puber

Persoon van 12 tot 16 jaar oud die sterke lichamelijke en geestelijke ontwikkelingen ondergaat.

thorax borststuk

Middelste deel van een insect, hieraan zitten de poten en vleugels vast.

tissue weefsel

Een groep cellen met dezelfde vorm en functie.

toadstool paddenstoel

Speciaal orgaan waar de sporen in ontstaan bij sommige schimmelsoorten.

toddler peuter

Kind van 1,5 tot 4 jaar; tijdens deze periode leert een kind onder andere praten en lopen.

transverse section dwarsdoorsnede

Dwars doorsnijden.

true-to-life drawing natuurgetrouwe tekening

Tekening waarin alle details zo nauwkeurig mogelijk staan.

tube tubus

Buis van een microscoop waarin het oculair zit.

tweezer-shaped beak pincetsnavel

Puntige snavel waarmee een vogel bijvoorbeeld in spleten kan komen en daardoor geschikt is om insecten mee te vangen.

U**unguligrade** topganger

Een dier dat op de toppen van zijn tenen loopt.

unicellular eencellig

Uit één cel bestaand.

V**vacuole** vacuole

Blaasje in plantaardige cellen dat gevuld is met vocht.

variation variatie

Kleine verschillen tussen organismen van dezelfde soort.

vascular bundle vaatbundel

Groep vaten die bij elkaar in een plant liggen.

vascular plants vaatplanten

Planten die vaten hebben voor het transport van stoffen.

vascular system vatenstelsel

Alle vaten van een plant.

veins nerven

Structuren in een blad die zorgen voor stevigheid en transport van water en andere stoffen.

vessels vaten

Lange dunne buisjes in de stengel van een plant die water, mineralen en glucose transporteren.

viviparous levendbarend

Levende jongen baren (in plaats van eieren leggen).

W**warm-blooded** warmbloedig

De lichaamstemperatuur is altijd even hoog.

woody plants houtachtige planten

Planten waarbij de stengels stevig zijn omdat ze veel hout bevatten.

work plan werkplan

Plan waarin staat beschreven hoe je een onderzoek wilt uitvoeren.

X**x-axis** x-as

Horizontale lijn in een grafiek.

Y**y-axis** y-as

Verticale lijn in een grafiek.

yeasts gisten

Eencellige schimmels.

young adult adolescent

Persoon van 12 tot 21 jaar; tijdens deze periode wordt de persoon geheel zelfstandig.

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